Appendix H.1.1

JPL/NASA Report on Laboratory Testing of Receivers for the Space-Based Sub-Team and the High Precision Sub-Team

JPL/NASA - Laboratory Testing

The following reports produced by the Space Sub-Team are assumed to be incorporated in the Space Sub-Team report, and are incorporated here by reference:

1. A preliminary report on the effects of CONDUCTED LightSquared emissions on four high precision GPS receivers
2. Analysis of LightSquared Base Station Emissions on NASA High Precision GPS Receivers

Appendix H.1.2

Trimble Live Sky Power Measurements – Las Vegas

Received Power Measurements

LightSquared's deployment plan has three phases, the Live Sky Las Vegas testing only fully addressed the phase 0 (one 5 MHz channel at 1550.2 MHz – 1555.2 MHz with an EIRP of 62 dBm). Phase 1 was partially addressed (two 5 MHz channels at 1526.3 MHz – 1531.3 MHz and 1550.2 MHz – 1555.2 MHz at 62 dBm per 5 MHz channel). However it was tested at a lower power level of 59 dBm per 5 MHz giving an overall EIRP of 62 dBm per antenna sector, versus the planned deployment of 65dBm per sector. Phase 2, which deploys two 10 MHz channels, was not tested. An additional but unplanned deployment was tested with 62 dBm EIRP in a single 5 MHz channel from 1526.3 MHz – 1531.3 MHz. In the following tables/figures the following nomenclature is used:

- Phase 0 = 1550.2 MHz – 1555.2 MHz = 5H
- Phase 1 = 1526.3 MHz – 1531.3 MHz & 1550.2 MHz – 1555.2 MHz = 5L + 5H
- Unplanned Phase = 1526.3 MHz – 1531.3 MHz = 5L

Power data tagged with location information was captured on nine consecutive nights (May 18th thru May 26th 2011 inclusive). Most nights there was at least an issue on one of the towers with it not conforming to the 62 dBm EIRP per antenna sector defined in the LightSquared test plan. The measured power data has been adjusted for periods when there was reduced power or deleted if there was no transmission or one with an unknown power level. This resulted in approximately 140,000 power measurements. The transmissions were supposed to occur in a 15 minute on / 15 minute off cycle between midnight and 6 AM synchronized to UTC. Unfortunately the transmissions were not completely synchronized to UTC, a best effort was made to eliminate data from the analysis when the transmitter was not on. However, there will be some epochs of data that remain. **Error! Reference source not found.** below indicates how the measured power data was adjusted to normalize to an EIRP of 62 dBm.

Table 1 Measured Power Adjustments

Date	Time	Mode	Tower	Issue	Note
2011-05-16		-	-	No data logged	No data available
2011-05-17		-	-	No data logged	No data available
2011-05-18	>= 12:30AM	5L+5H	217	59dBm EIRP	Add 3dB after 12:30AM
2011-05-18	12:00AM – 02:30AM	5L+5H	68	Site Outage due to rectifier problem	Data deleted 12:00AM – 03:30AM
2011-05-18	>= 03:00AM	5L+5H	68	59dBm EIRP	Add 3dB after 03:00AM
2011-05-19	>=12:30AM	5H	160	59dBm EIRP	Add 3dB after 12:30AM
2011-05-19	>=12:30AM	5H	53	59dBm EIRP	Add 3dB after 12:30 AM
2011-05-20	>=12:30AM	5L+5H	160	59dBm EIRP	Add 3dB after 12:30 AM
2011-05-20	>= 12:30AM	5L+5H	53	59dBm EIRP	Add 3dB after 12:30 AM
2011-05-21	12:30AM – 12:45AM	5L	217	59dBm EIRP	Add 3dB between 12:30 – 12:45
2011-05-21	12:30AM - 12:45AM	5L	68	59dBm EIRP	Add 3dB between 12:30 – 12:45
2011-05-22	12:00AM – 05:45AM	5H	-	No issues (62dBm EIRP)	
2011-05-23	< 12:30AM	5L	217	Site had an amber alarm and did not transmit	Data deleted 12:00AM – 12:30AM
2011-05-24	12:00AM – 01:30AM	5L+5H	53	Transmitter Cabling Error	Data deleted 12:00AM – 01:30AM
2011-05-25	01:34:35AM – 01:41:52AM	5L	53	Experimenting with different receive antennas	Data deleted
2011-05-25	02:04:55AM- 02:12:20AM	5L	53	Experimenting with different receive antennas	Data deleted
2011-05-26	12:00AM - 05:45AM	5L+5H	-	No issues (62dBm EIRP)	
2011-05-27		-	-	No data logged	No data available

During the test four towers were active. The rural tower (53) was located in Boulder City remote from the three Las Vegas towers. The Las Vegas towers were relatively spread out compared to the planned deployment of 400-800 m (dense urban) and 1-2 km (urban)[1]. To protect the Las Vegas and Boulder City airports from the

[1] LightSquared Responses to NTIA Questions, 2011-02-24

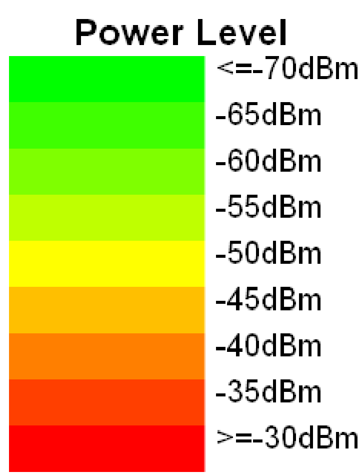
LightSquared signals, towers 53 and 217 only had two antenna panels mounted instead of the usual three. Table 2 below provides the locations of the towers.

Table 2 Tower Locations

LightSquared Site ID	Latitude	Longitude	Antenna Height AGL (ft)	Number of Sectors	Azimuths (degrees)	City
LVGS0053-C1	35.9697	-114.8681	60	2	30, 270	Rural
LVGS0068-C1	36.1245	-115.2244	55	3	0, 120 ,240	Suburban
LVGS0160-C1	36.127	-115.189	50	3	0, 120, 240	Urban
LVGS0217-C1	36.1065	-115.1705	235	2	0, 240	Dense Urban

The following sections contain many plots that superimpose power measurement data onto map data to show the location where the power measurement was made. The colors used to show the power data is proportional to the measured power. Figure 1 shows the colors used in 5dB increments; the data however is drawn in a continuous color scale.

Figure 1 Measured Power Intensity Legend



The LightSquared transmit antenna provides 16.8 dBi gain in the main beam of each antenna; vertically the antenna has a very narrow beamwidth, horizontally there are also approximately 7 dB nulls in the gain pattern when three antennas are combined, as shown in Figure 2. In addition to variations in local obstructions, the antenna gain pattern explains why we see varying power at a common radial distance from a tower but at different azimuths. In the plots and analysis that follow no attempt has been made to cancel or model the azimuth variation of the transmit antenna.

The effect of line of sight and azimuthal pattern variation is best illustrated with the power levels measured from the downtown tower (Tower 217 Dense Urban). Figure 3 gives the measured LTE signal power as measured into a 0 dBi antenna on the ground. The plot is annotated with areas of seemingly odd measurements. Figure 4 shows the power measurements in the context of the local environment using the colors in Figure 1 to display the power level. There are three locations noted with Red circles on Figure 4 that have a direct line of sight to the transmitter and thus the power approaches the theoretical value. One of the three locations is directly in view of the main bean of the sector antenna and shows the highest power levels. Alternately, one of the three is in the direct null between two sector antennas and shows less power but still high compared to the surroundings. There are two locations noted with Blue circles that show very low powers. These areas were measured in places where the sector antenna was missing or on the low gain portion of the sector antenna.

Figure 2 LightSquared Transmitter Three Sector Antenna Gain

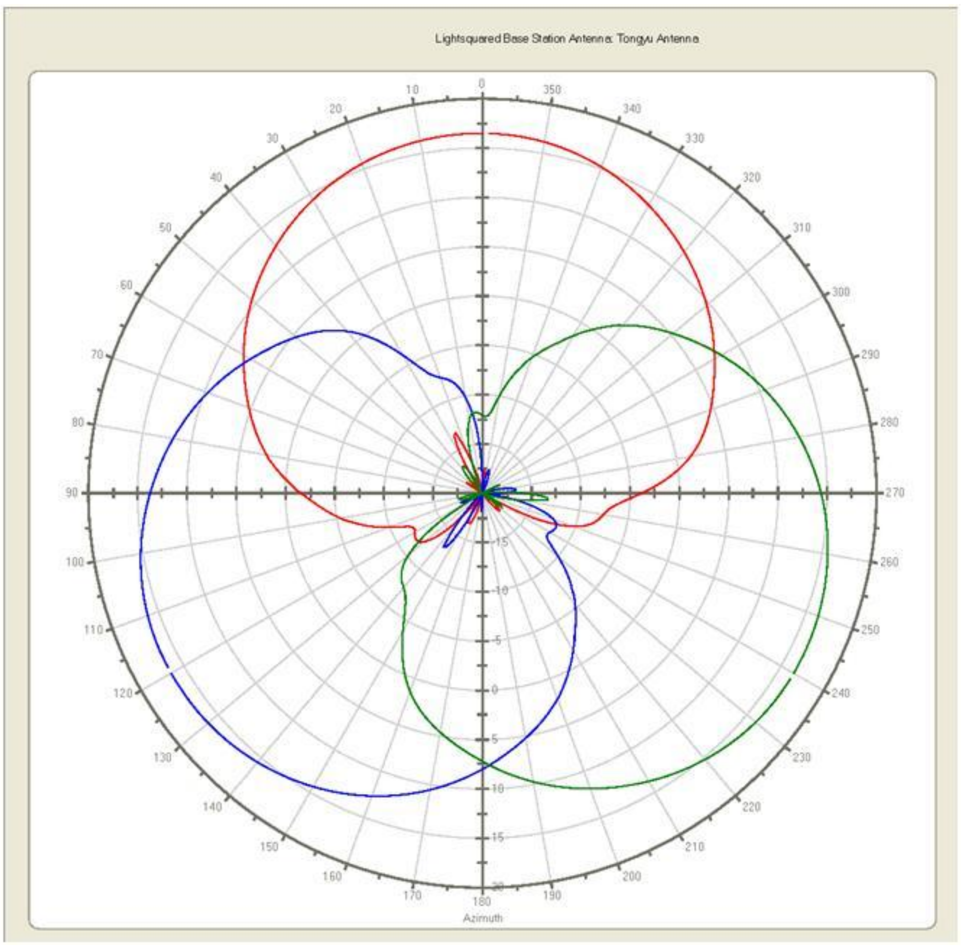


Figure 3 Tower 217 - LTE Power Variations due to Tower Configuration

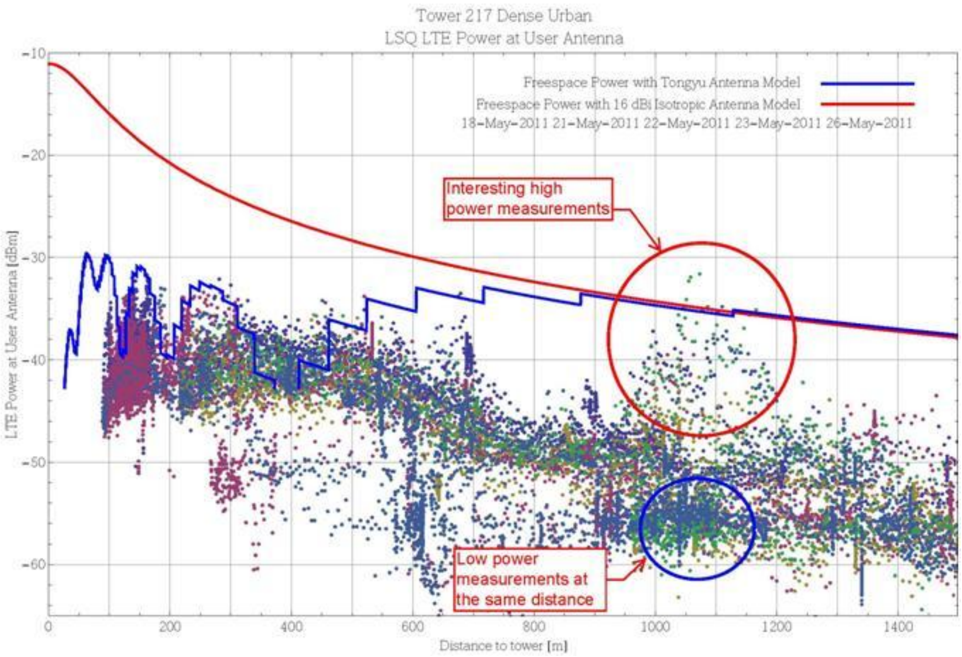
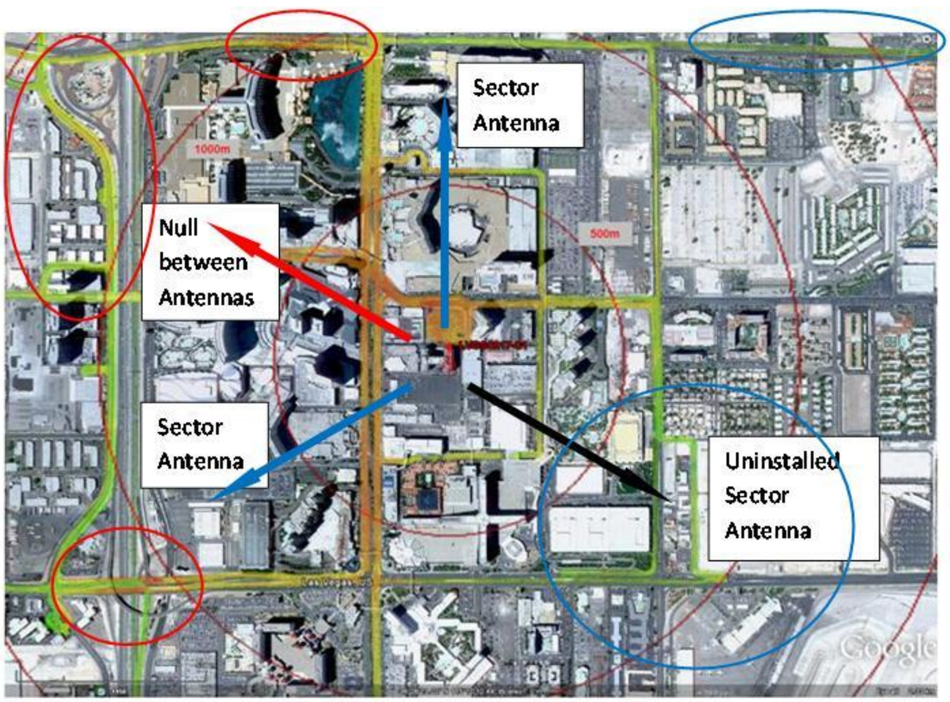


Figure 4 Measured Power around Tower 217



Power Measurements for each Tower

The following section presents power measurement data for each of the four towers used in the Las Vegas Live Sky Testing. At least two figures are presented for each tower. The first provides a map view with the ground colored according to the power level as described in Figure 1, with radius rings shown from each tower in steps of 500m.

Figure 5 Measured Power at Tower 217

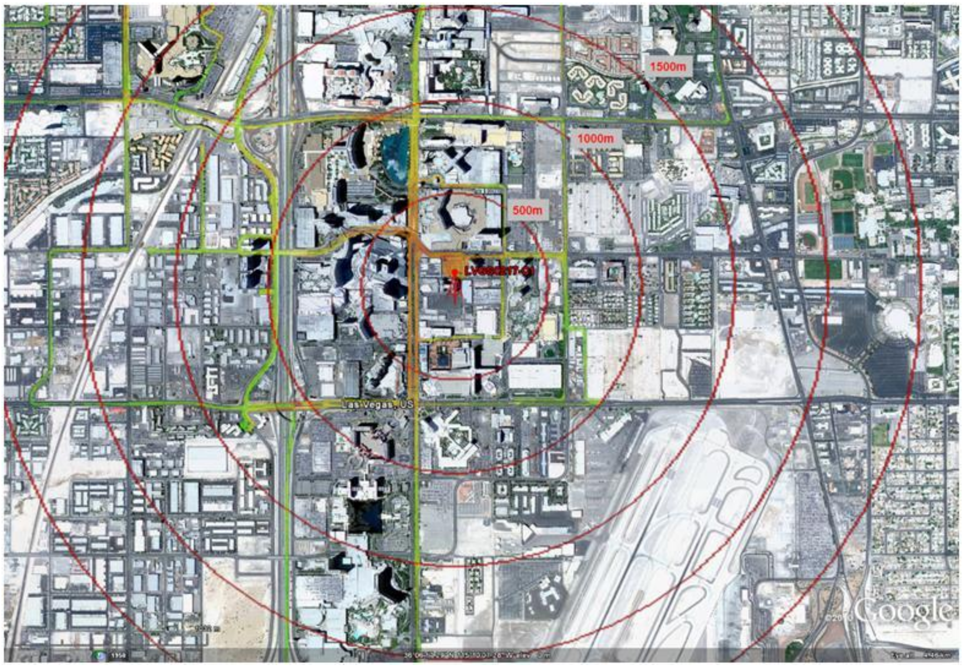


Figure 5 gives a map view of the measured power data at the dense urban tower 217; this data is shown as a function of distance to the tower in Figure 6. Out to 500 m the received power matches very well the free space loss model after the impact of the transmit Tongyu antenna is considered. Beyond 500 m in this dense urban environment there are periods where the WI LOS model may better fit the data (-38.5 dBm at 600 m, -41.8 dBm at 800 m and -44.3 dBm at 1 km). However, for a GPS overload perspective the worst case should be considered and it can be seen that the data does start to peak again and approach free space loss at 1 km, due to better line of sight to the tower at some azimuths. In order to protect the Las Vegas airport a panel was not loaded at 120 degrees (see Figure 2) and some of data from this analysis was collected in this large null and has biased the average of the data downwards. It is recommended that we use the free space model after accounting for the transmit antenna elevation dependent gain profile in this environment.

Figure 6 Received Power versus Range for Tower 217

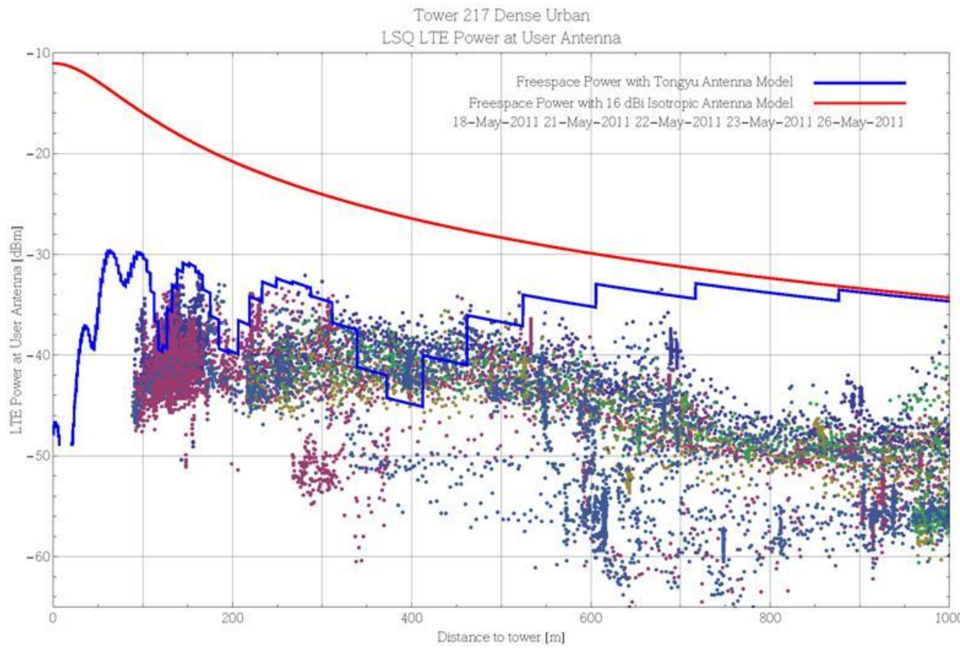


Figure 7 shows a map view of the power data logged at tower 160, the urban tower. A considerable amount of data was logged in a parking lot to the North West of the tower and along a road due south of the tower. Only after completing the testing and analyzing the data was it discovered that while there is still considerable power measured at these azimuths, both of these areas are in approximately 7dB transmit antenna nulls, see Figure 2. In Figure 8 we show the measured power as a function of distance to the tower, as data was collected in the antenna nulls along with regular propagation effects it explains the large data spread. From a GPS overload perspective we want to understand the worst case propagation and again the free space model provides a very good approximation out to 500m. Beyond 500m the data is between free space and the WI LOS model.

A short representative time series was plotted in **Figure 9**, it shows the measured power as function of time while driving around tower 160.

Figure 10 shows where the vehicle drove during this 15 minute test. It can be seen that during static periods the measured power is extremely stable and even while driving the short term multipath fading is only on the order of 10 dB.

Figure 7 Measured Power at Tower 160

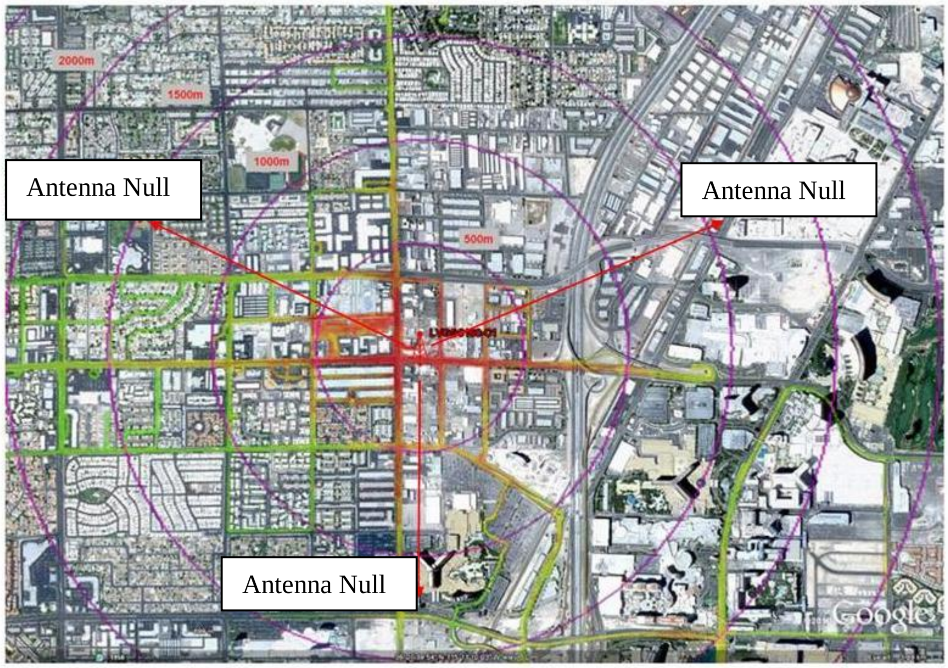


Figure 8 Received Power versus Range at Tower 160

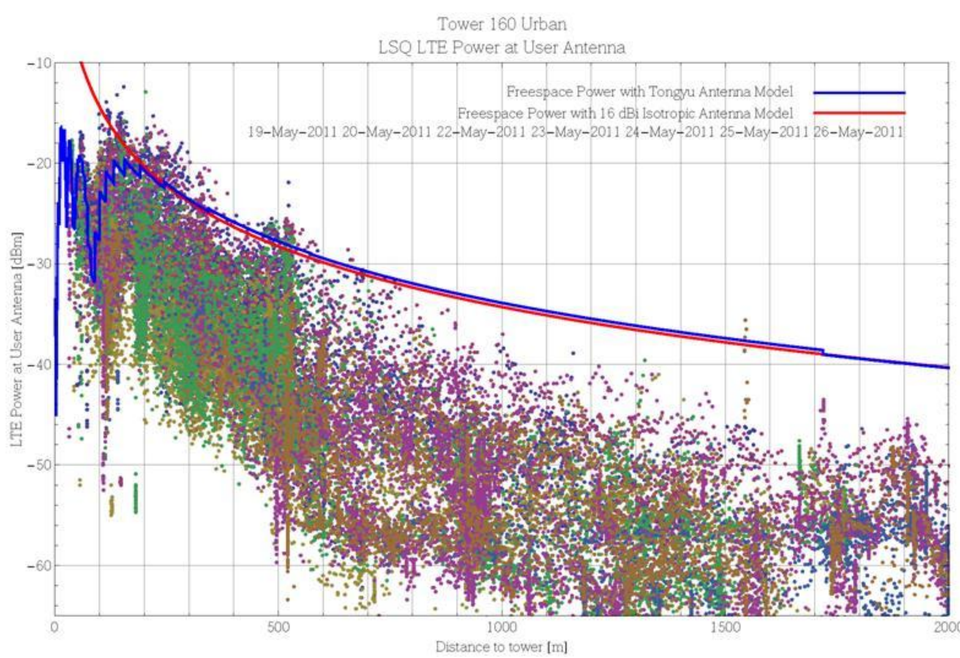


Figure 9 Power Measurements against Time around Tower 160

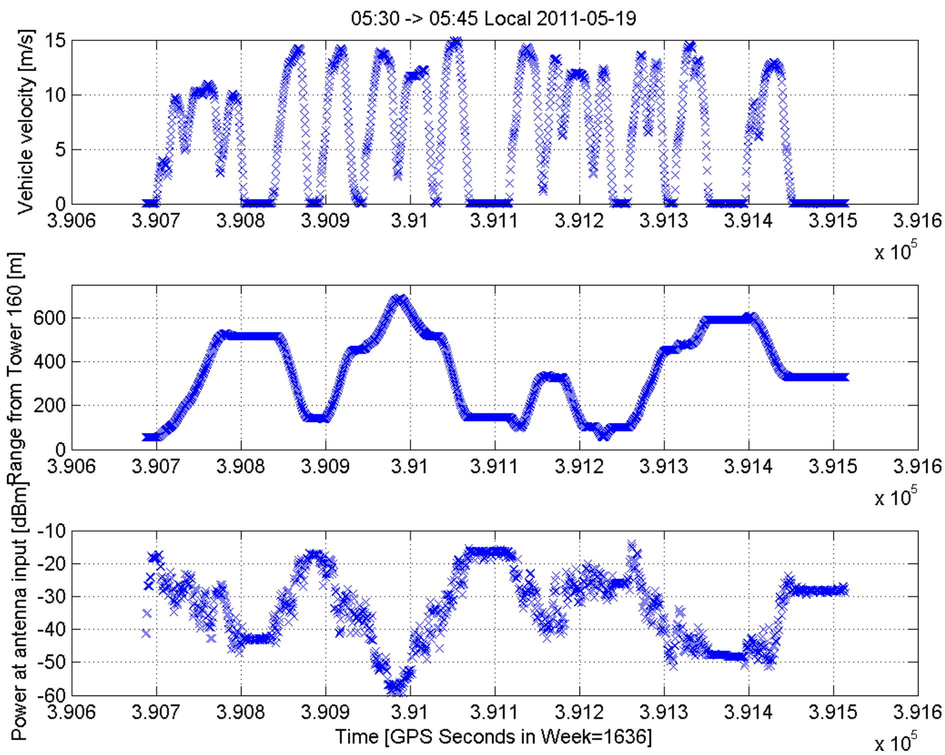


Figure 10 Power Measurements around Tower 160 (05:30 - 05:45 (Local) 2011-05-19

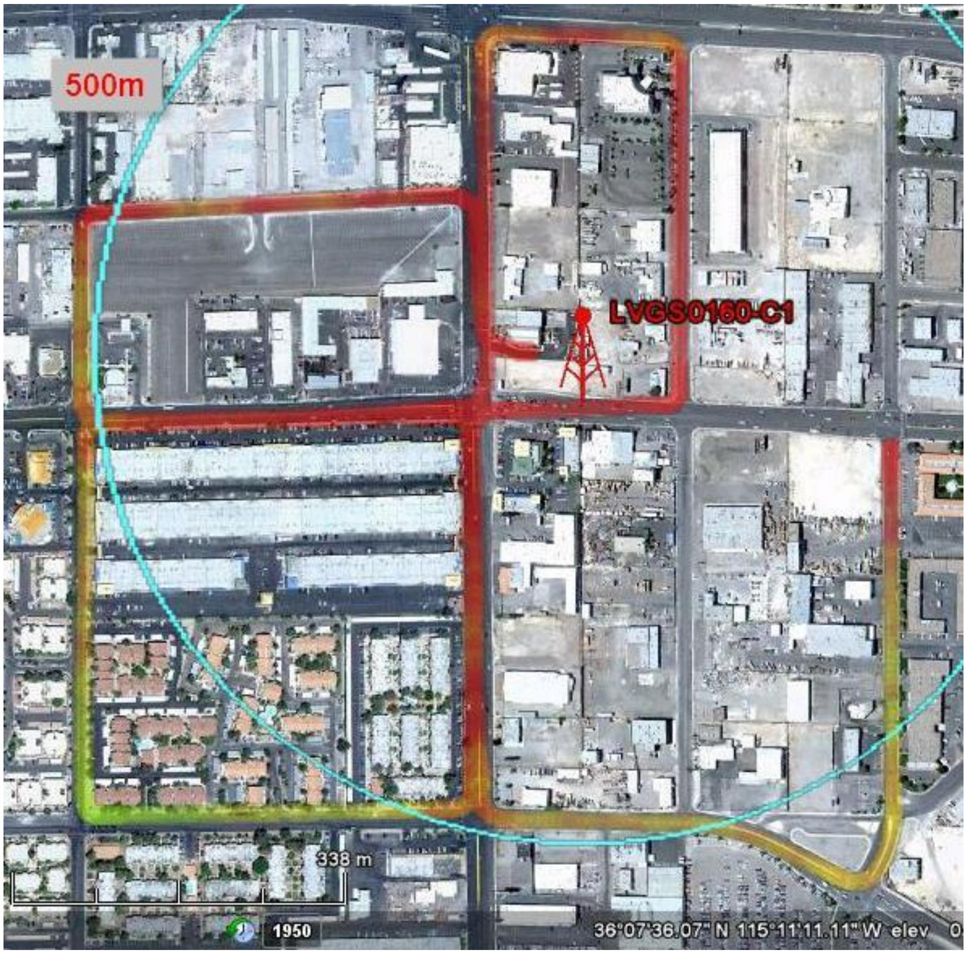


Figure 11 shows a map of the measured power data for tower 68. Three antenna panels were mounted at this site with gain nulls at 60, 180 and 300 degrees azimuth (see Figure 2). Considerable data was again logged in these nulls, especially to the south which is directly in the null and to the East and West which are about 5 dB down relative to the center line of the transmit antenna panels. The power measurement data is shown as a function of distance to the tower in Figure 12. This data shows very good agreement to free space again out to 500 m. Beyond 500 m there are less measurements at the free space power level, but as we want to protect from worst case impact we should still consider a free space model as clearly at some locations we are measuring free space path loss to the transmit antenna.

Figure 11 Measured Power at Tower 68

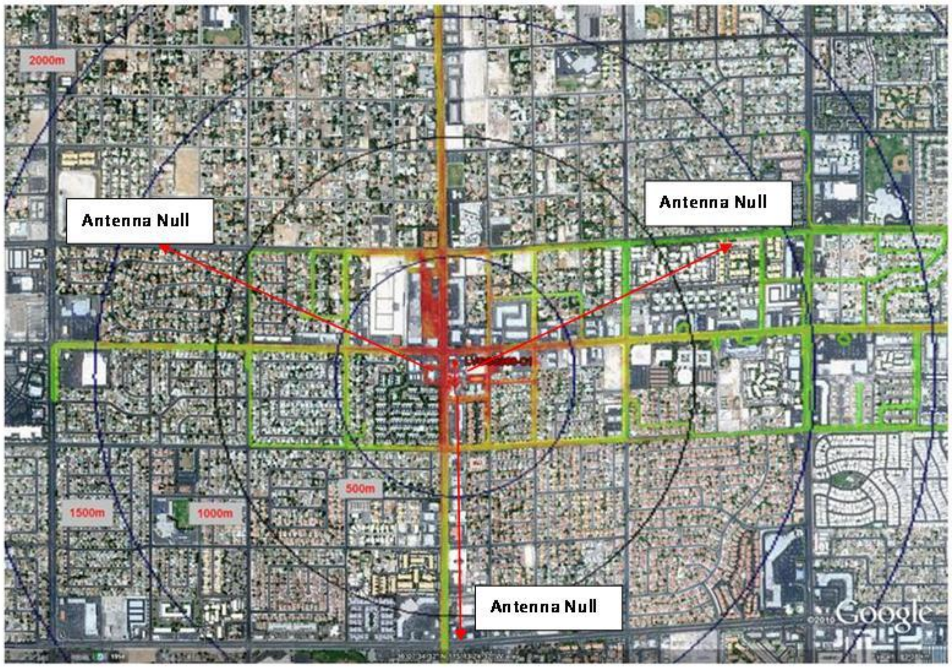


Figure 12 Received Power versus Range for Tower 68

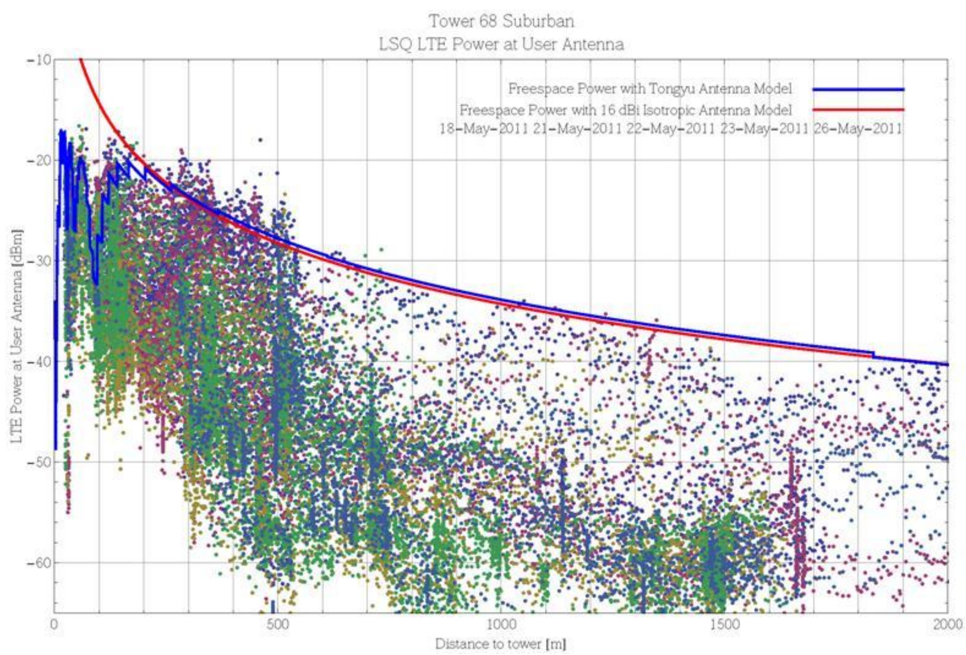


Figure 13 maps the received power within a few km of the tower 68 (the rural tower). Unfortunately, there are few roads around the tower so there are only limited locations power can be measured. Further reducing the value of the data around this tower only two panels were loaded to protect the Boulder city airport from jamming and the transmit antenna array was rotated by 30 degrees relative to the rest of the deployed towers. This resulted in a null due East of the tower which is where one of the only roads available roads is located. The 7 dB points of the null extend from 90 degrees to 210 degrees with virtually no power radiated at 150 degrees. Data was collected in the antenna null and makes the measured power versus range shown in **Figure 15** optimistic.

Figure 14 shows the power measured at approximately 8.5 km from the rural tower. Power was measured as high as -44 dBm in this area which was high enough to jam several precision GPS receivers during the test. This remote location had a direct line of sight to the transmit tower as the lights on the tower could be seen clearly by the team collecting the data.

Figure 13 Received Power at Tower 53

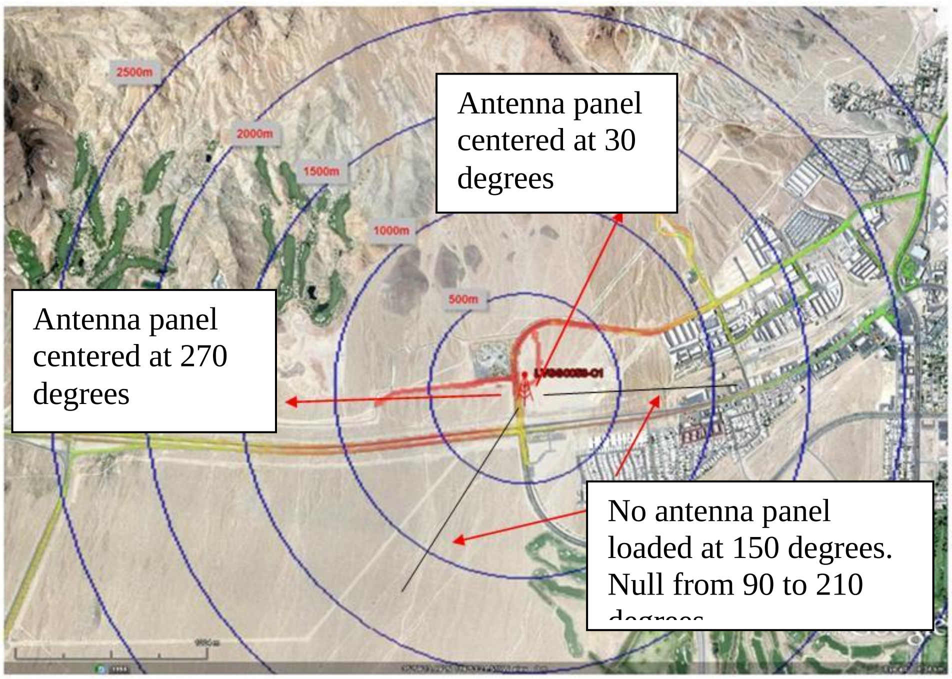


Figure 14 8.5 km South West of Tower 53

Figure 15 shows the measured power out to a range of 2 km from tower 53. Figure 16 extends the data out to approximately 9 km. For the majority of the dataset a free space loss model fits the data best from a GPS receiver overload perspective.

Figure 15 Receiver Power versus Range at Tower 53 (0 – 2 km)

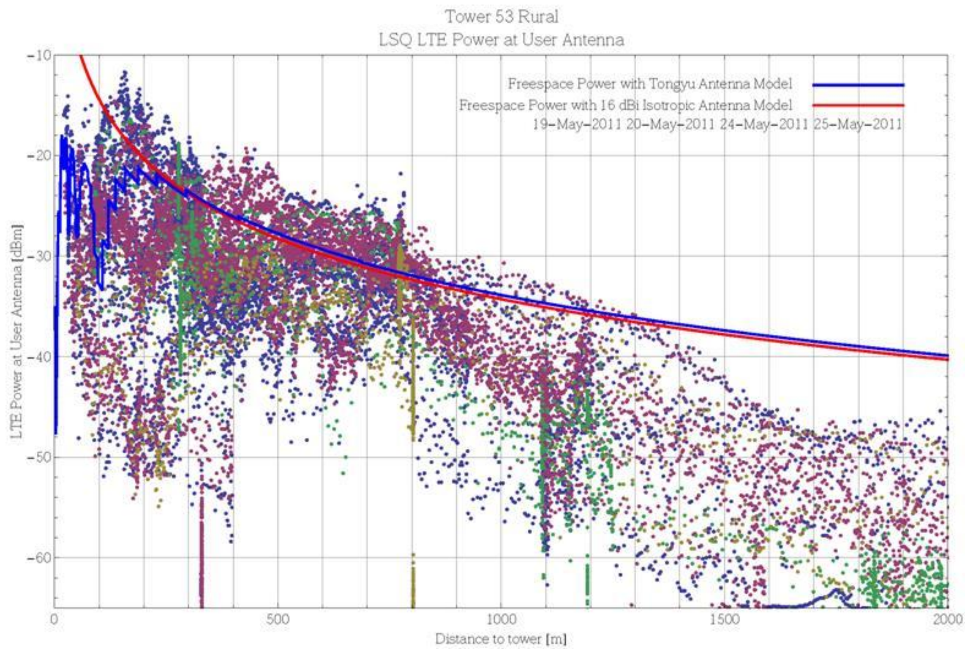
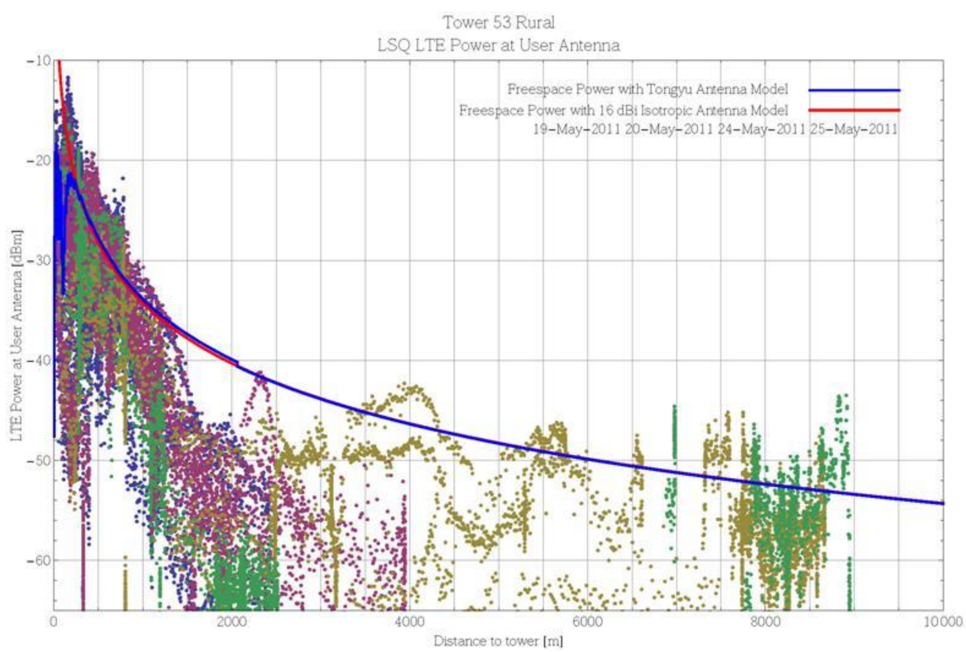


Figure 16 Received Power versus Range at Tower 53 (0-10 km)



The measured power data comprised of approximately 140,000 points. However in several cases the test vehicle was static during part of the test. To analyze the power distribution at spatially separated locations, the data was filtered so that the vehicle had to move more than 1 m before the power data was used. This reduced the data set to approximately 103,000 points with unique locations. This data is plotted giving both the range to the tower and received power as a distribution for each tower in Figure 17 to Figure 20 and an extended range for Tower 53 in Figure 21.

Figure 17 Range and Power Distribution for Data Logged within 2 km of Tower 217

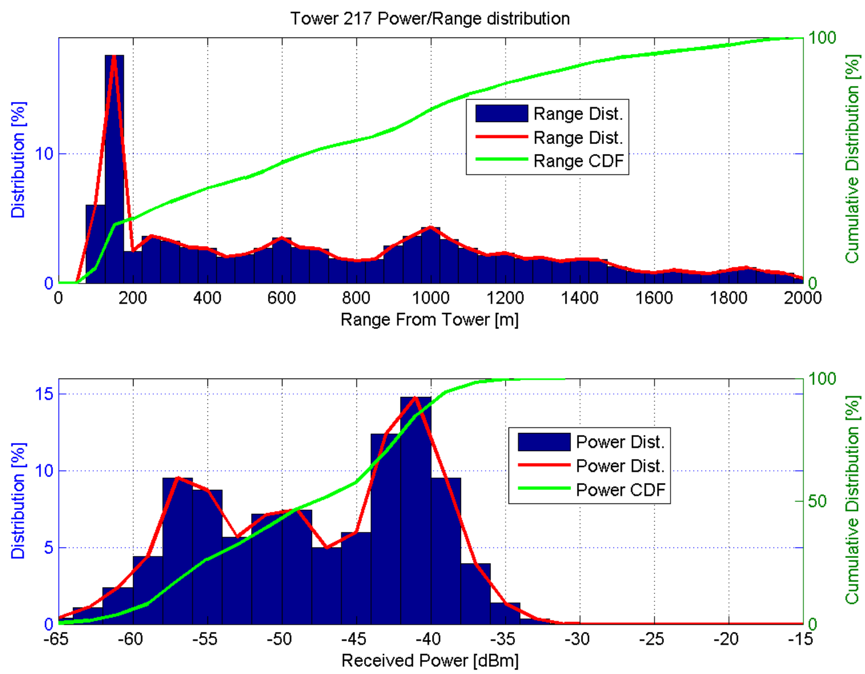


Figure 18 Range and Power Distribution for Data Logged within 2 km of Tower 160

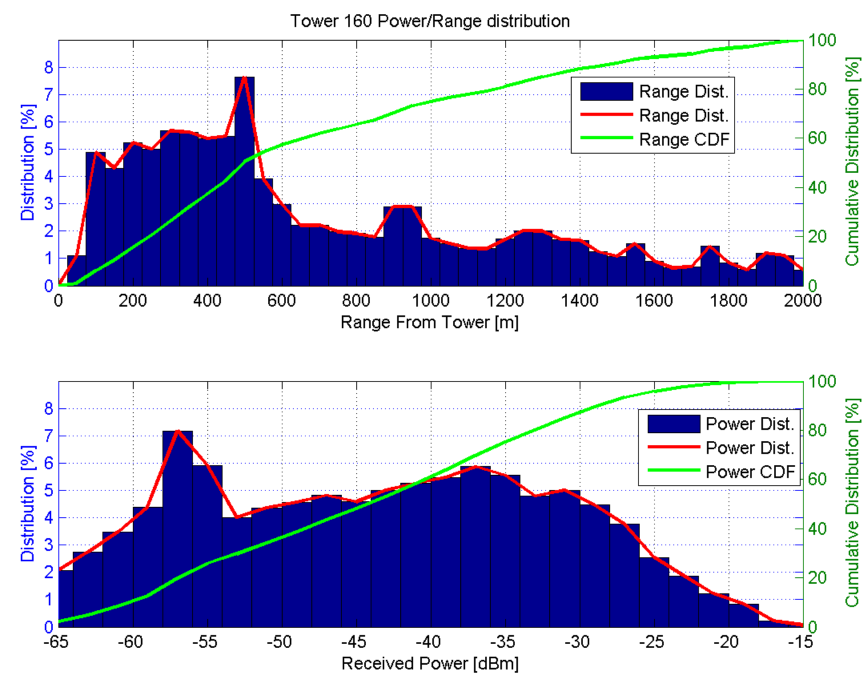


Figure 19 Range and Power Distribution for Data Logged within 2 km of Tower 68

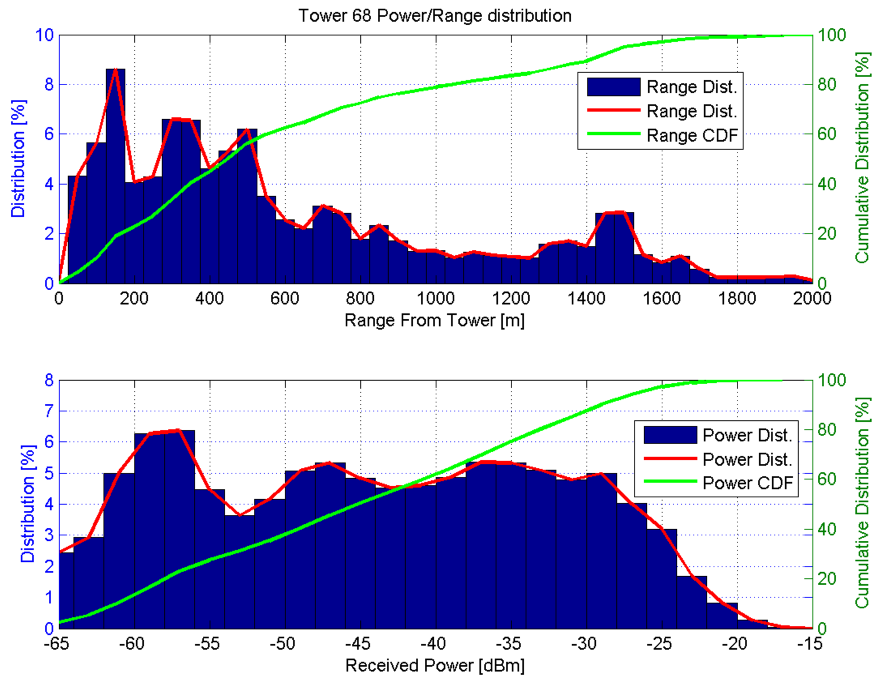


Figure 20 Range and Power Distribution for Data Logged within 2 km of Tower 53

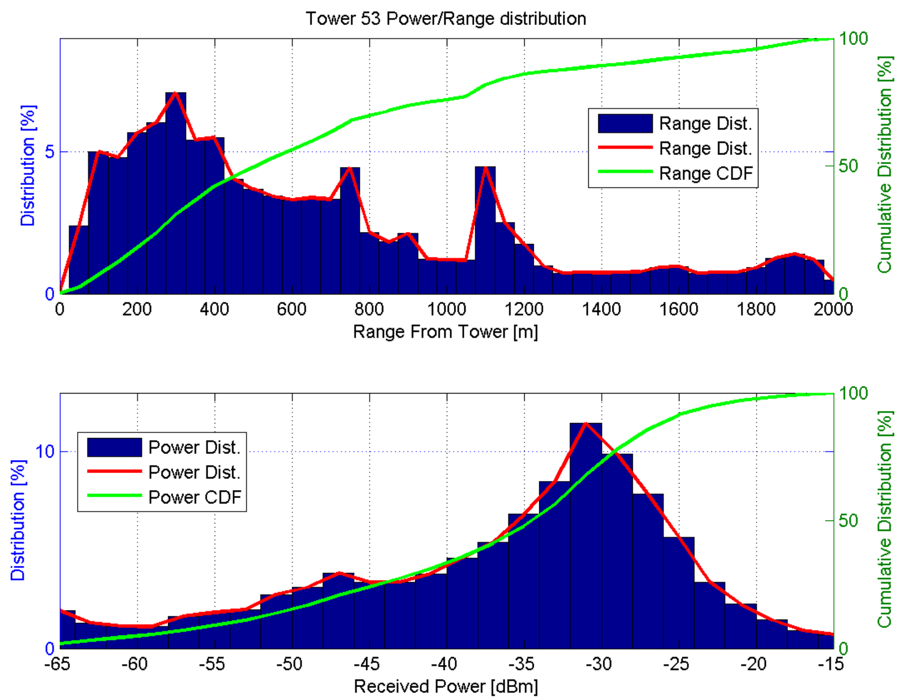
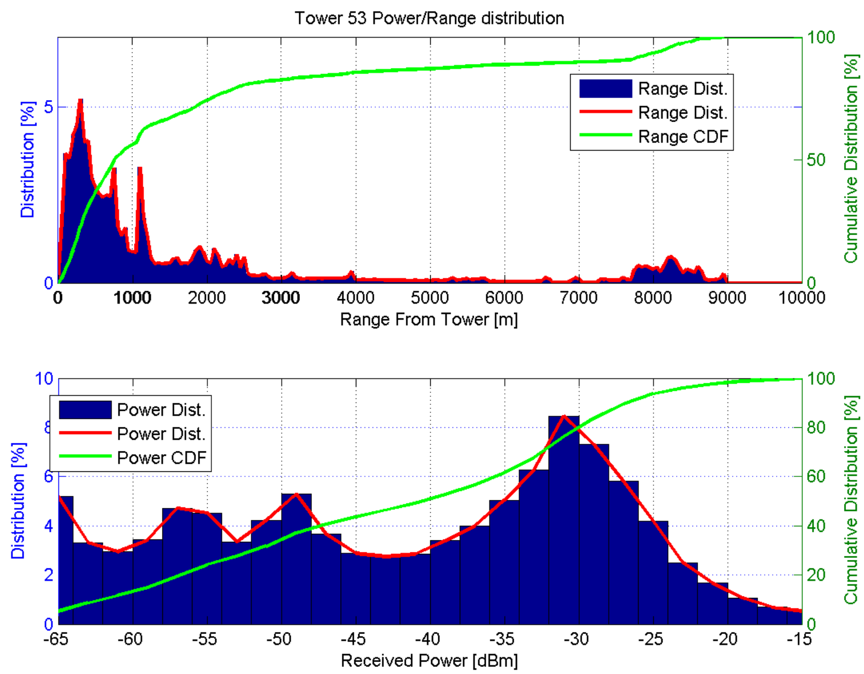


Figure 21 Range and Power Distributions for Data within 10 km of Tower 53

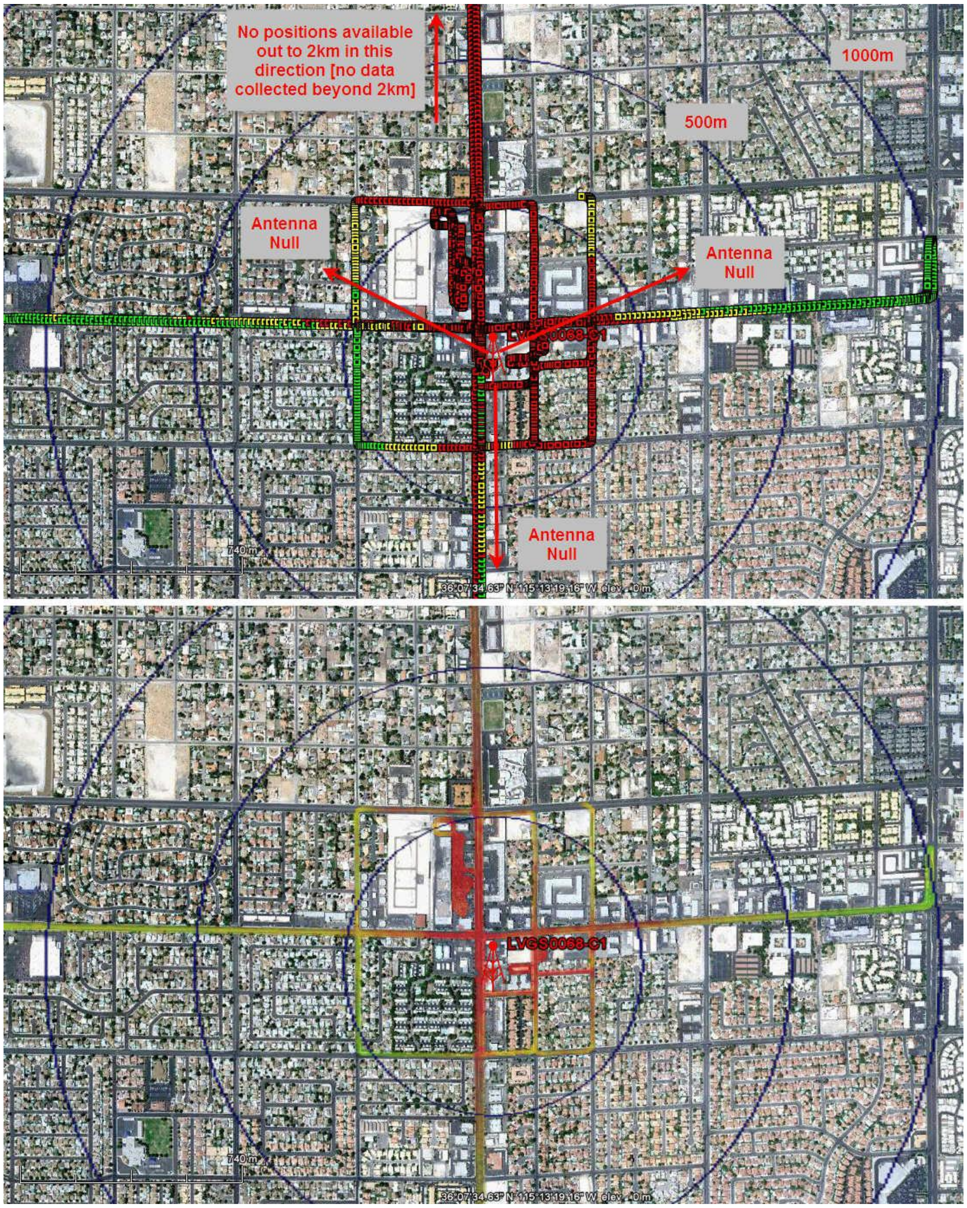


Impact on Precision Positioning

To assess the impact of the LightSquared signal on a precision receiver's ability to produce a high quality position the solution type was monitored. If the narrow bandwidth receiver used to geotag the power data was able to position but the high precision was not, the data was plotted in red. If the high precision receiver was able to position but not in a high precision mode (e.g., RTK fixed) the data was colored in yellow. If the receiver was delivering a precision position (RTK fixed) the data was colored green. However, even when the data is green the solution can be degraded due to a reduced number of satellites tracked and/or lower C/N_0 due to the LightSquared jammer.

Figure 22 shows the position performance of a high precision receiver attempting to perform RTK around tower 68. The impact of the antenna nulls are also clearly visible with the performance due North of the tower being worst as it directly in the center line of one of the transmit antenna panels. The precision receiver was not able to position in any mode out to 2 km from the tower at which point the van was turned around so it is not known for how far the precision GPS denied zone extended. Even when the receiver is able to position in an RTK fixed mode the C/N_0 is typically impacted reducing the robustness and potentially the accuracy of the solution.

Figure 22 H90730 Positioning Performance for 2011-05-18 (5L+5H)



The upper portion of Figure 22 shows the positioning performance during this test (no position (red), low precision position (yellow), high precision position but potentially degraded due to reduced C/N_0 (green)). The lower portion shows the measured power. As expected, there is a strong correlation between measured power and the unavailability of a precision GNSS solution. The LightSquared EIRP was 62 dBm before 3AM (3 dB lower than the planned deployment) and 59 dBm after 3AM (6 dB lower than the planned deployment).

Figure 23 C/N_0 versus Time for 2011-05-18 (5L+5H).

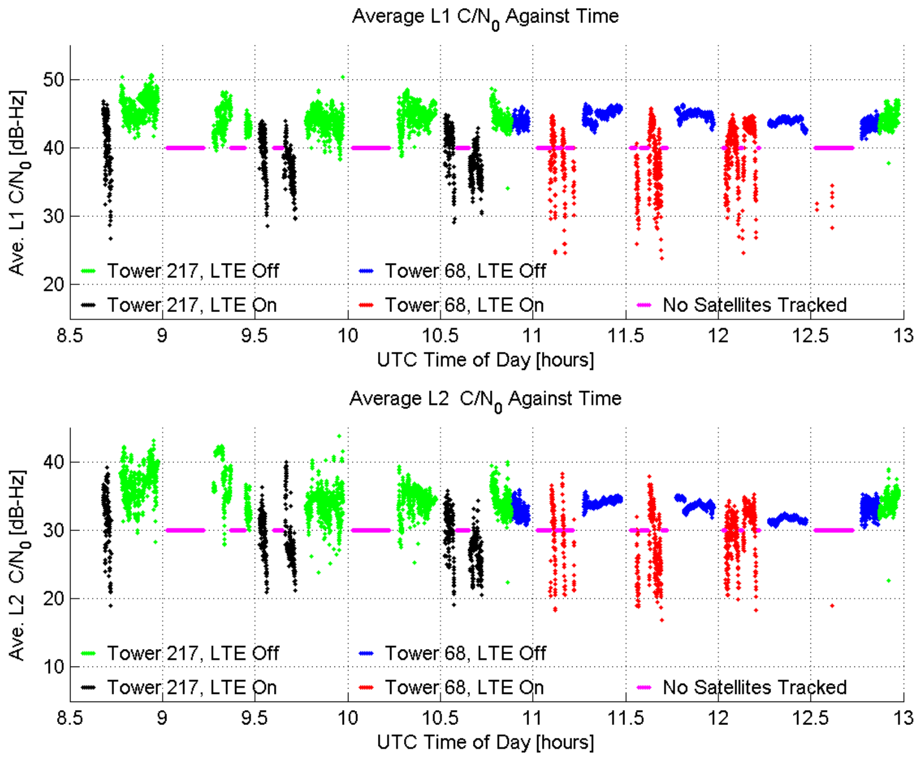
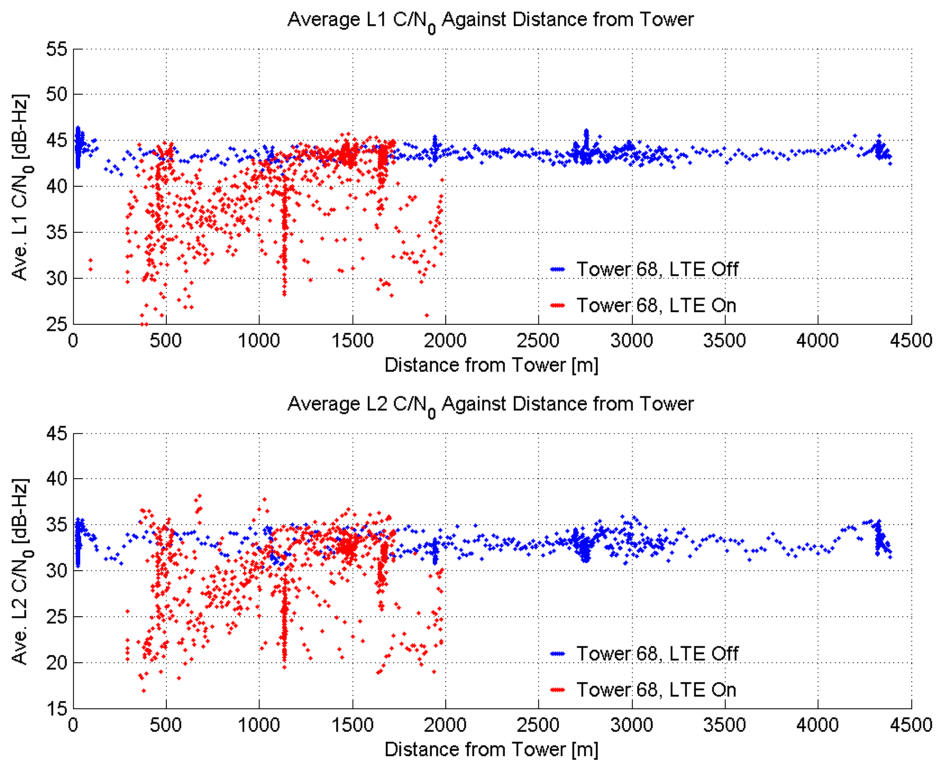


Figure 23 shows the data logged on the May 28th . During the first part of the test the receiver was located close to tower 68. However, the LightSquared transmitter had problems and was in an unknown state until 2:30AM (0930 UTC). Therefore data prior to 2:30 AM (0930 UTC) has been eliminated from the Figure 23 analysis. The graph shows the average C/N_0 across all satellites that are phased locked for both periods when the LTE transmitter was on and also when it was off. During periods when the jammer is on either no satellites are tracked (magenta point is drawn) or the average C/N_0 is significantly degraded. In Figure 24 this same data is plotted as a function of range from tower 68. As the LTE transmit schedule was not perfectly synchronized to UTC for both Figure 23 and Figure 24, 90 seconds was erased from the data set either side of the planned transmitter switch on/off times.

Figure 24 Average C/N_0 as a Function of Distance from Tower 68 on 2011-05-18



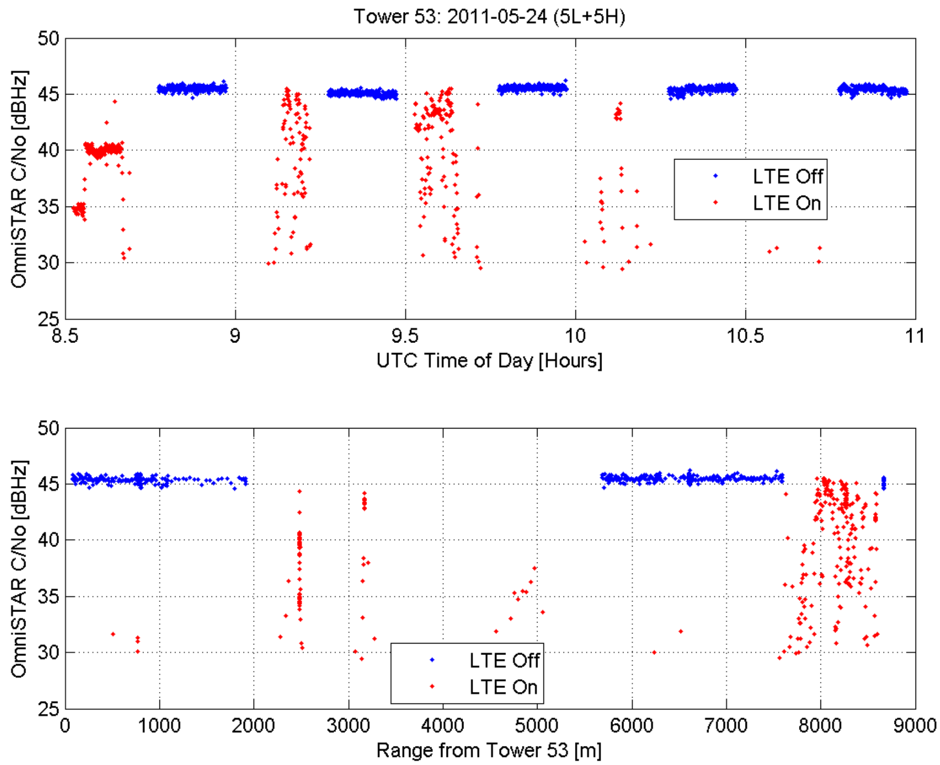
OmniSTAR/StarFire

OmniSTAR and StarFire are commercial high precision correction services giving sub-decimeter real time positions. These systems use satellite down links in the L-band MSS band (1525 – 1559 MHz). A typical receiver that processes these signals uses a wideband antenna/LNA which receives the whole band from the bottom of the MSS band (1525 MHz) to either the top of the GPS L1 band or the top of the GLONASS L1 band at approximately 1610 MHz.

The LightSquared signal is an in-band jammer to the satellite delivery of OmniSTAR and StarFire. In the case of OmniSTAR, LightSquared's MSS satellite service is used as the delivery mechanism. As MSS frequencies can get shifted or reallocated (e.g., the agreement between Inmarsat and LightSquared to swap spectrum), in order for a manufacturer of an OmniSTAR or StarFire capable receiver to assure they are future proof to any changes in MSS satellite spectrum allocation between providers, the receiver must be designed to receive any signal in the 1525 – 1559 MHz band.

Figure 25 provides an OmniSTAR tracking plot from the Las Vegas testing. This data was collected in the immediate vicinity of Tower 53 and then South to the area approximately 8.5 km from the tower at which high LightSquared power was observed during the testing (see **Figure 14**). The tracking against time as well as a function of range from the tower is shown. The OmniSTAR tracking is almost completely jammed out to 8.5 km and even out at that range the tracking is significantly degraded.

Figure 25 OmniSTAR Tracking Performance at Tower 53



Appendix H.1.3

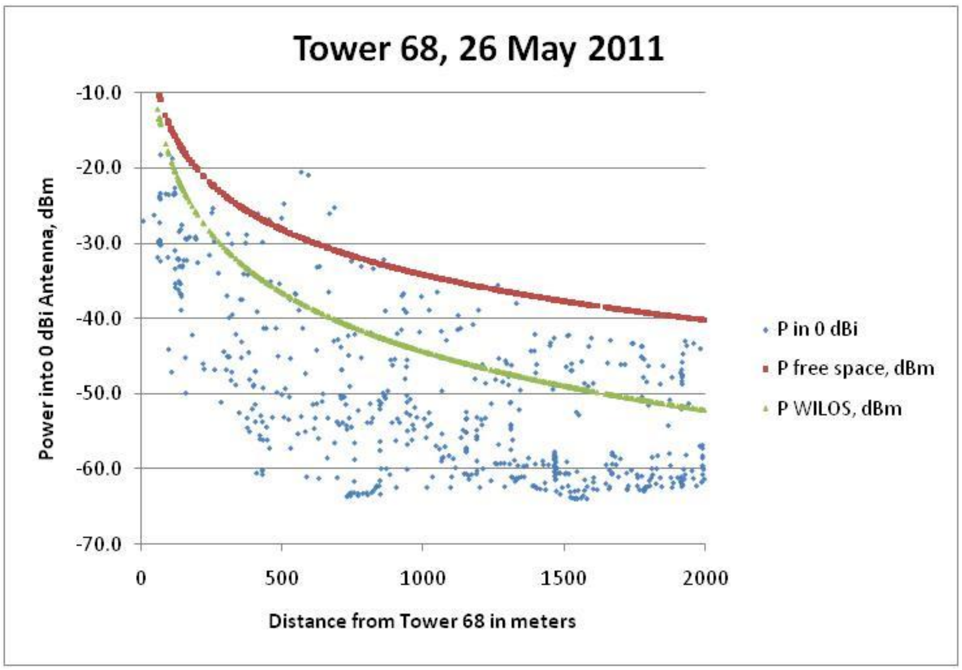
Deere Live Sky Power Measurements – Las Vegas

Live Sky LTE Power Measurement Results

Tower 68 - Suburban

The Deere team emphasized collecting data from the rural Tower 53, and most of the urban and suburban data was gathered on 26 May 2011 when all four sites were transmitting. Since the collection region was large and multiple sites were transmitting the points in Figure 26 are limited to 2 km so that power from the other urban sites can be minimized. For comparison purposes two popular propagation models are also plotted, the free space ($1/R^2$) and the Walfisch-Ikegami Line of Sight (WILOS), based on a transmit power of +62 dBmi.

Figure 26 vs. Distance from Suburban Tower 68



Tower 160 - Urban

Figure 27 shows that the LTE propagation in a more urban environment is less effective than a suburban environment, as expected.

Tower 217 - Dense Urban

Figure 28 shows that the dense urban results were similar to the urban. Note that the antenna pattern variation is not accounted for in the two propagation model curves. This can reduce the received power by more than 10 dB when closer than 600 m to the tower.

Figure 27 Power vs. Distance from Urban Tower 160

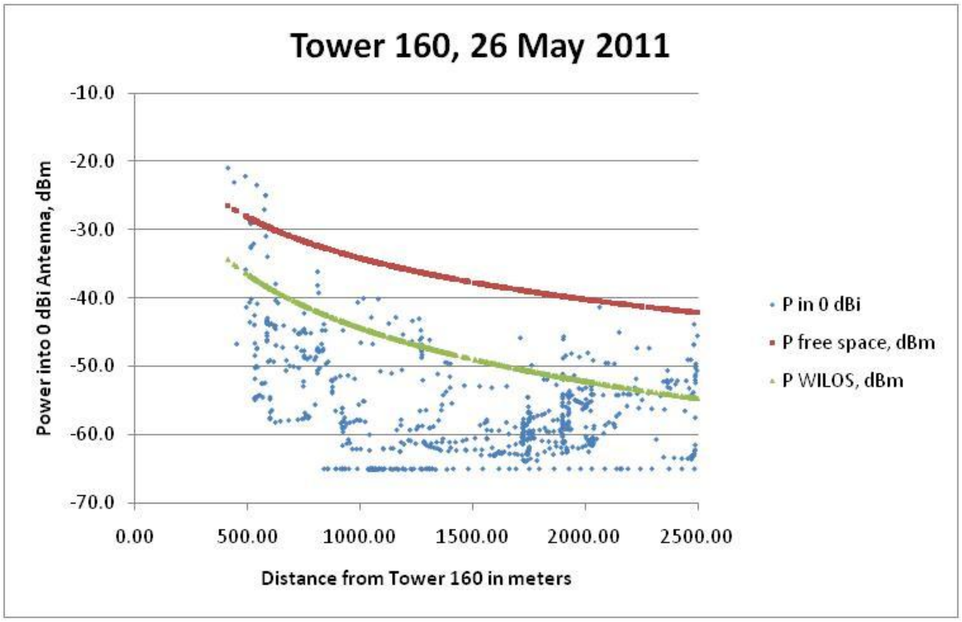
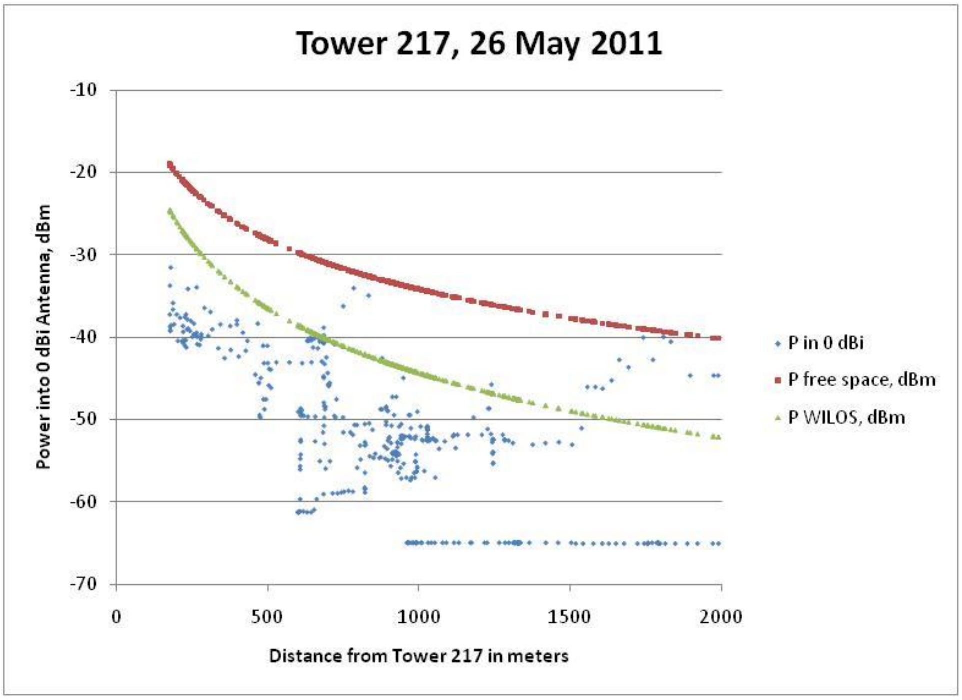


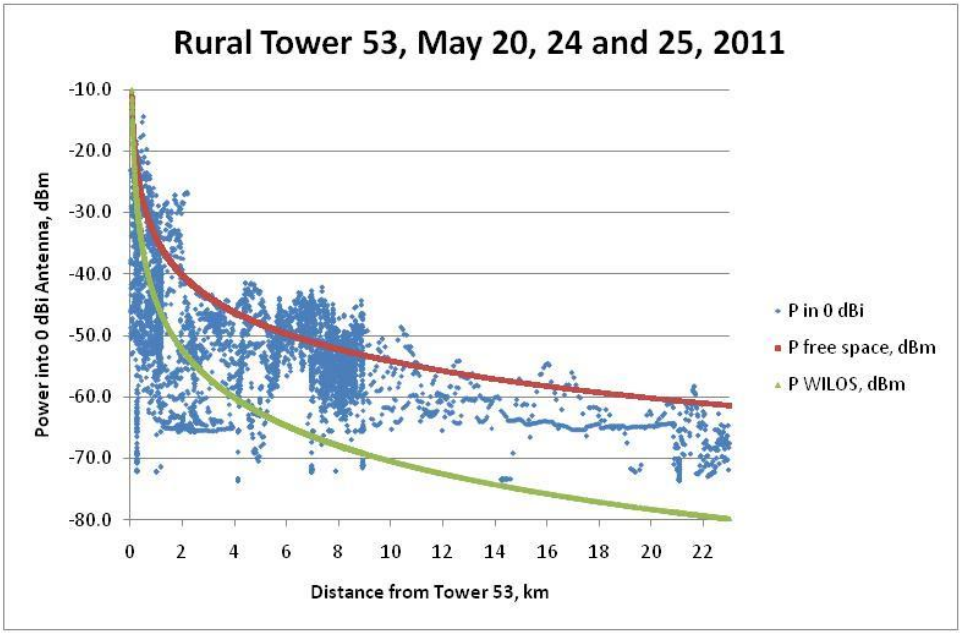
Figure 28 Power vs. Distance from Dense Urban Tower 217



Tower 53 - Rural

This tower was situated near Boulder City in a spot which afforded literal line of sight views of up to 20 km. Figure 29 shows that the mobile unit was receiving between -60 and -70 dBm at a distance of 22 km from the LTE source.

Figure 29 Power vs. Distance for Rural Tower 53



GNSS Receiver Testing

Although mapping the received LTE power was the primary objective for the High Precision Sub-Team in Las Vegas, it was also used as an opportunity to observe receiver performance with actual GPS satellites and LTE sources in an open air environment. Trimble, Deere, Hemisphere and Topcon logged receiver performance during some part of the two week test period.

Rural GPS Measurements

Rural GPS Measurements – 20 May 2011

Tower 53 was in the dual 5 MHz mode. Figure 30 shows the C/N_0 for both the L1 C/A code and the L2 PY code for two SF3050 (Solaris) receivers. Note that the color coding is synchronized to the LTE power turning on and off. Likewise Figure 30 C/N_0 vs. Time for 2 SF3050 Receivers - 20 May 2011

shows the same information for a pair of SF3000 receivers.

Figure 30 C/N_0 vs. Time for 2 SF3050 Receivers - 20 May 2011

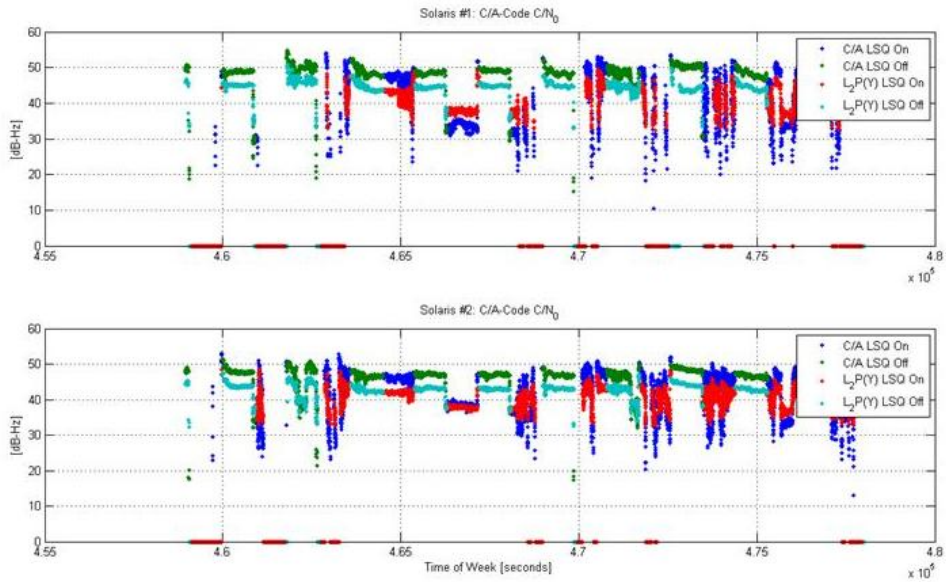
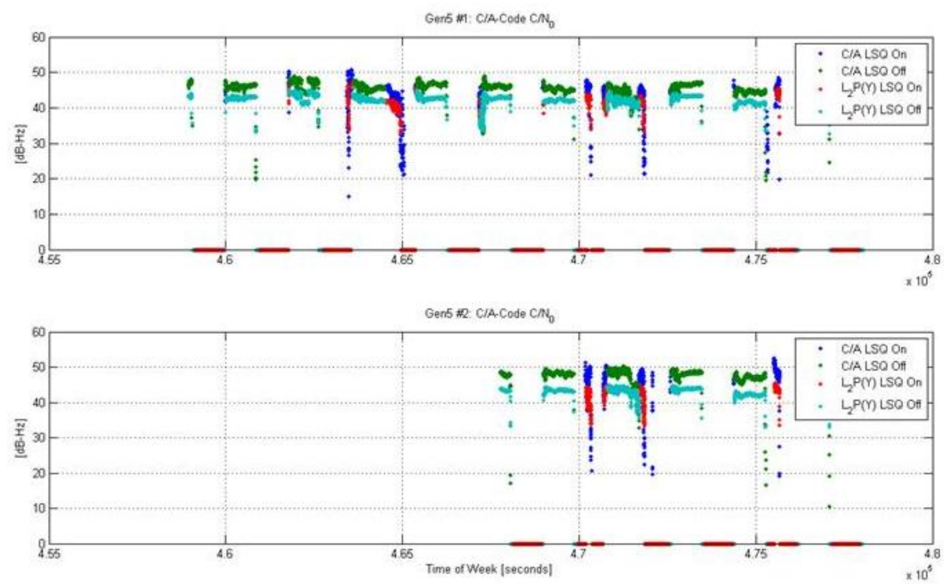


Figure 31 C/N_0 vs. Time for 2 SF3000 Receivers - 20 May 2011



The C/N_0 vs. time plots are a good historical record of the test, but do not convey information about the effect of distance from the LTE tower on C/N_0. For that we have prepared plots of received C/N_0 vs. distance. In these plots C/N_0 is calculated by averaging C/N_0's for the SV's with phase lock. The measurements from between 90 seconds before an ON-OFF transition and 90 seconds after the transition are not displayed because of imperfect synchronization and because the receiver takes some time to acquire the GPS signals after LTE shutoff. Figure 32, Figure 33, Figure 34, and Figure 35 show the C/N_0 readings for the same four receivers over a 9 km range from Tower 53. The SF3000 receiver had to get to 15 km from the tower before the tracking became reliable. Beyond 15 km it was able to maintain phase lock, but experienced over 1 dB of degradation. The second SF3000 had a configuration problem and stopped sending data after 9 km.

Figure 32 C/N_0 vs. Distance from Tower 53 for SF3050-1 Receiver - 20 May 2011

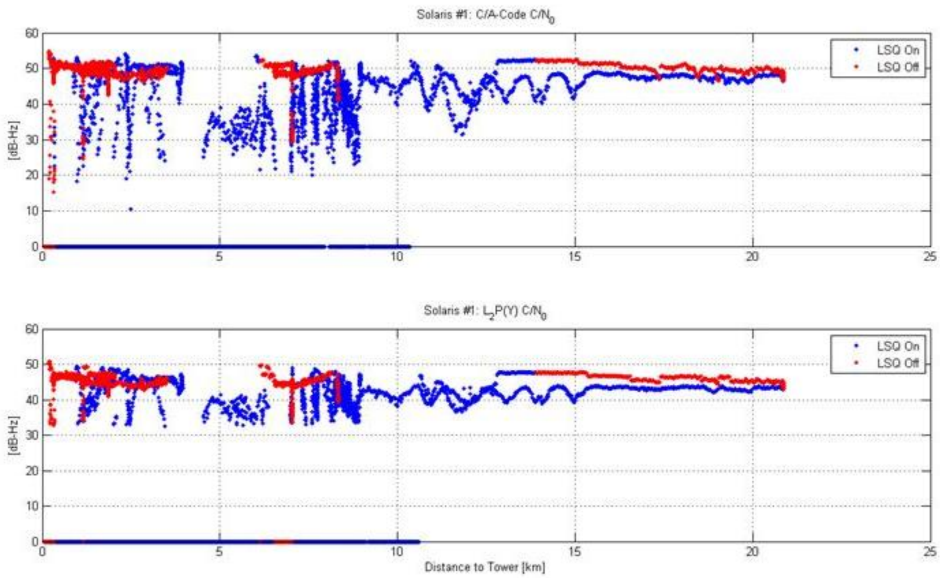


Figure 33 C/N_0 vs. Distance from Tower 53 for SF3050-2 Receiver - 20 May 2011

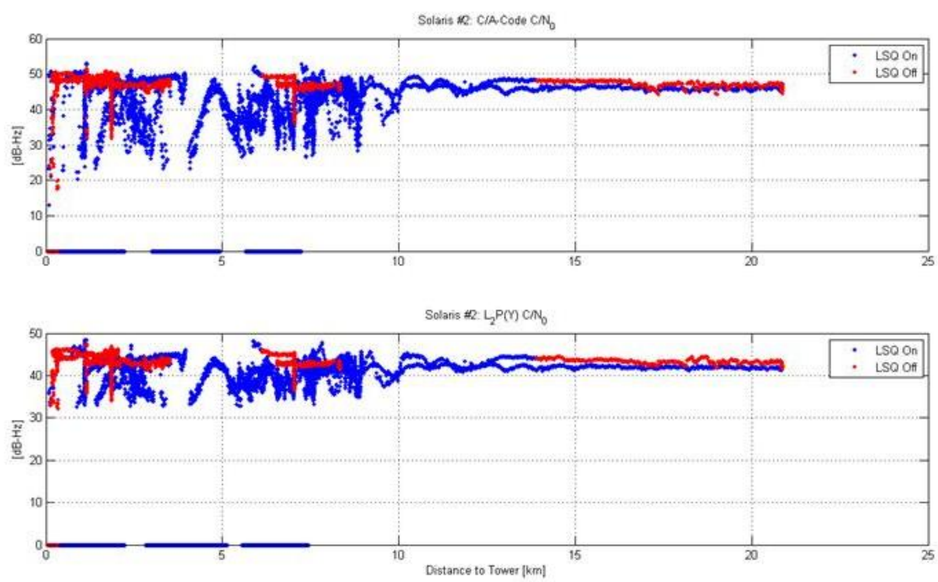


Figure 34 C/N$_0$ vs. Distance from Tower 53 for SF3000-1 Receiver - 20 May 2011

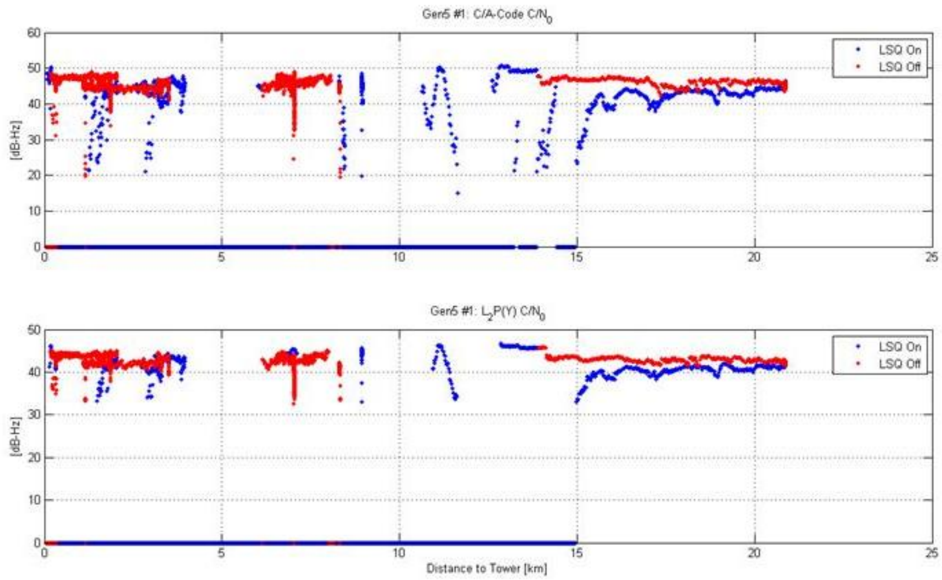
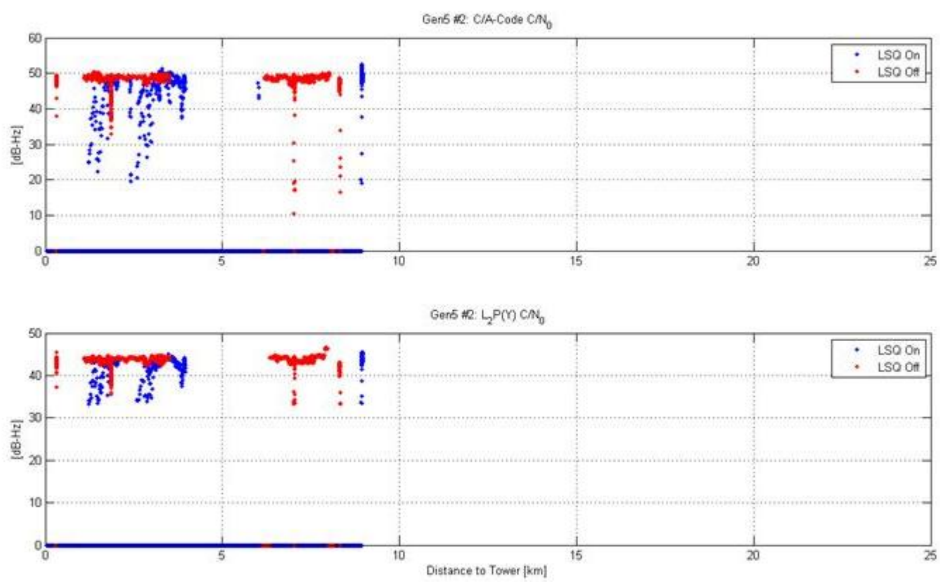


Figure 35 C/N$_0$ vs. Distance from Tower 53 for SF3000-2 Receiver - 20 May 2011



Another useful display of receiver performance in the presence of LTE power is a plot of SV count vs. distance to LTE source. Figure 36 and Figure 37 show the number of SV's for which the receiver has phase lock vs. distance. On this day, even receivers from 15 km to 18 km from the tower experienced a reduction in tracked SV's from 12 SV's to 8 SV's when the LTE signal was on.

Figure 36 SV Count vs. Distance from Tower 53 - SF3050 Rx - 20 May 2011

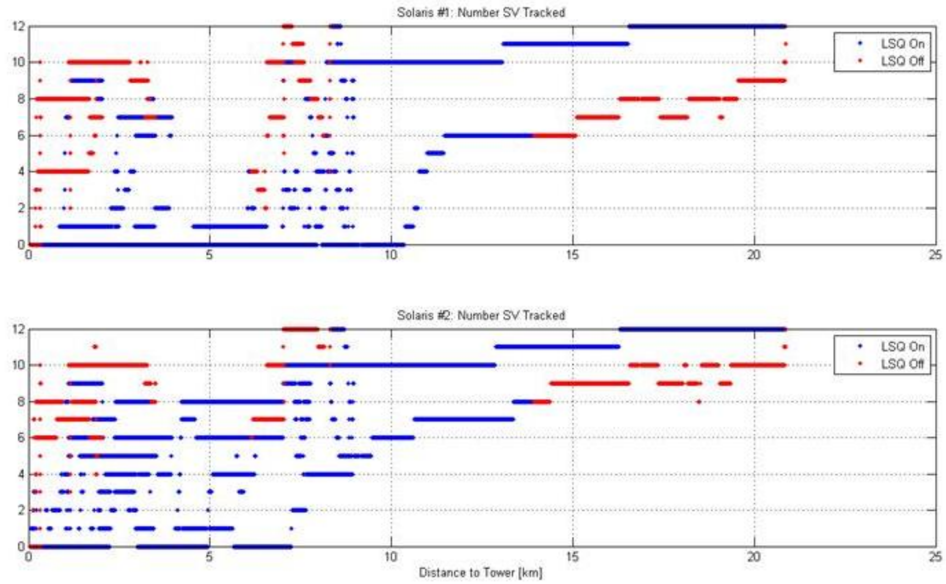
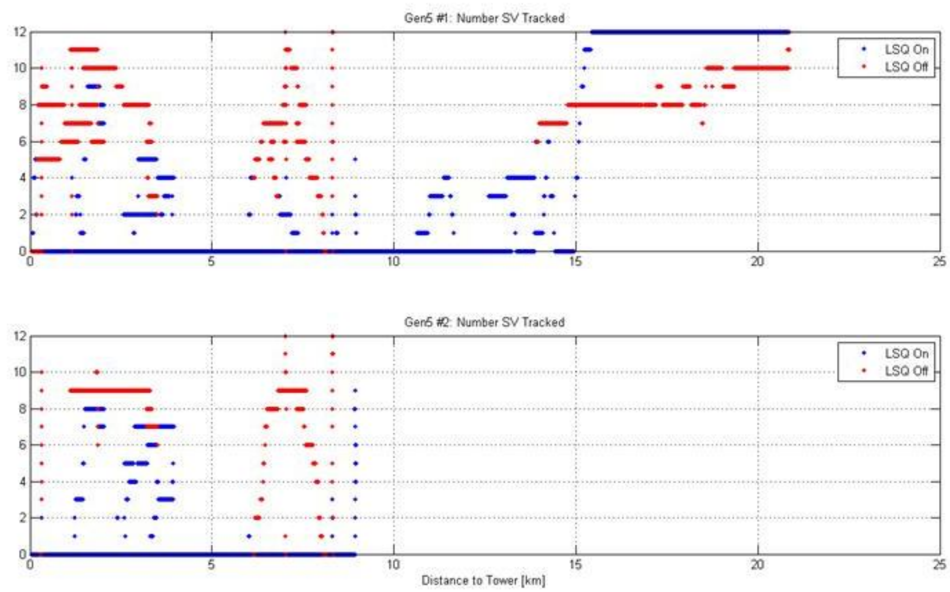


Figure 37 SV Count vs. Distance from Tower 53 - SF3000 Rx - 20 May 2011



Rural GPS Measurements – 25 May 2011

Tower 53 was in the low 5 MHz mode. This day's expedition covered much of the same route as on 20 May 2011 except that the upper 5 MHz band was off. Figure 38 and Figure 39 show the C/N_0 vs. time for the two receiver types.

Figure 38 C/N_0 vs. Time for SF3050 Receivers - 25 May 2011

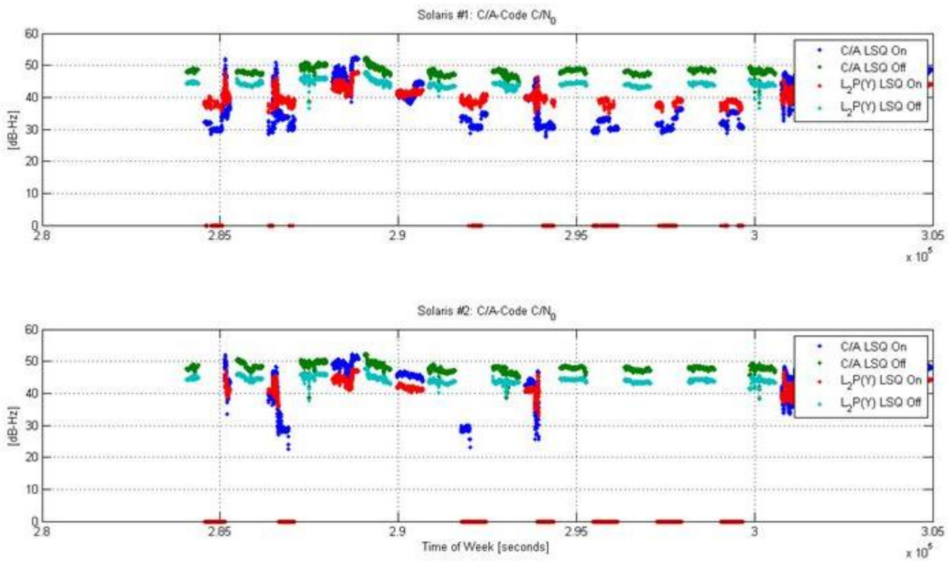
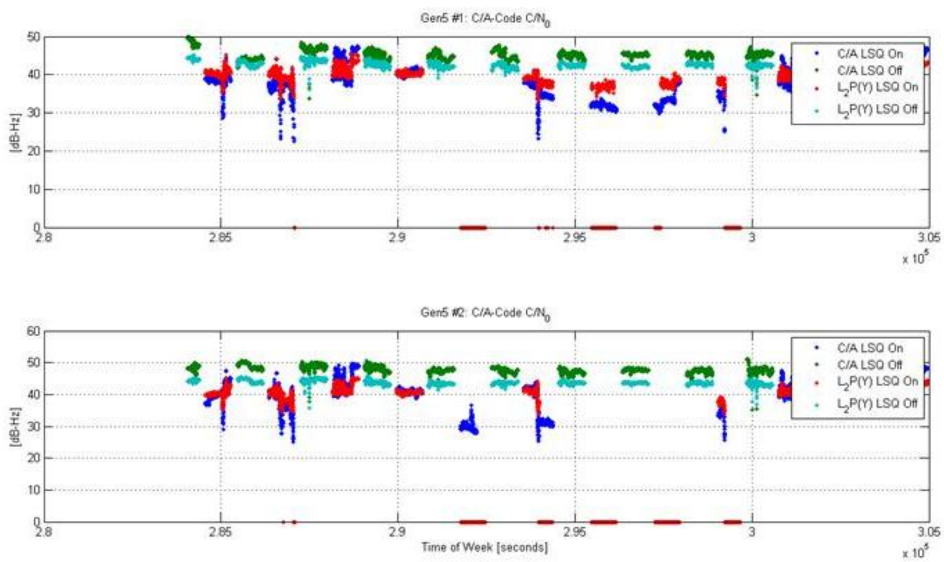


Figure 39 C/N_0 vs. Time for SF3000 Receivers - 25 May 2011



The received C/N0 for C/A code and for L2 PY code is plotted in Figure 40, Figure 41, Figure 42, and Figure 43. It can be seen that there is degradation within 10 km, but the LTE effects are minimal at greater than 15 km. The data collected from about 11 km to 16 km from the LTE transmitter is not shown because it falls within the ±90 seconds from the ON-OFF transition time, and the van was in motion.

Figure 40 C/N_0 vs. Distance from Tower 53 for SF3050-1 Rx - 25 May 2011

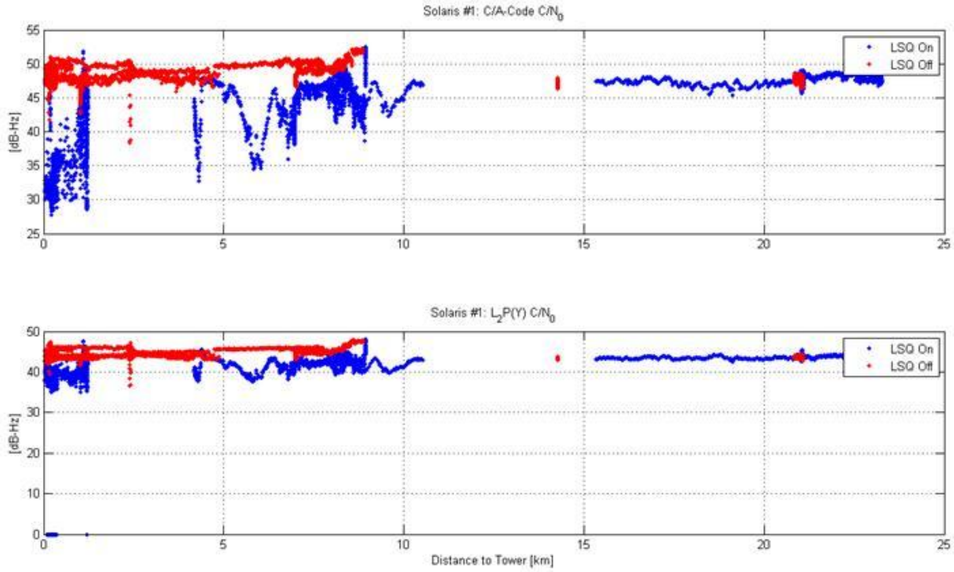


Figure 41 C/N_0 vs. Distance from Tower 53 for SF3050-2 Rx - 25 May 2011

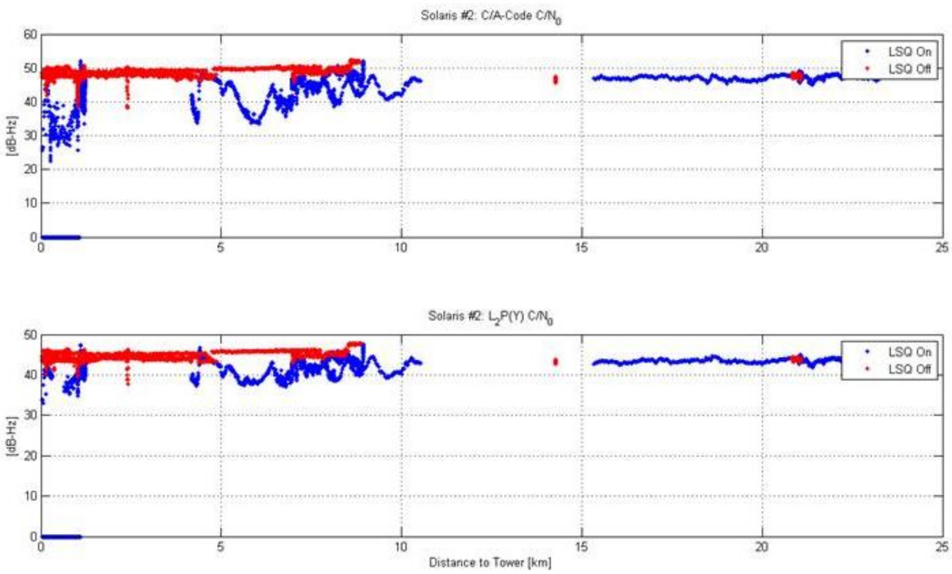


Figure 42 C/N$_0$ vs. Distance from Tower 53 for SF3000-1 Rx - 25 May 2011

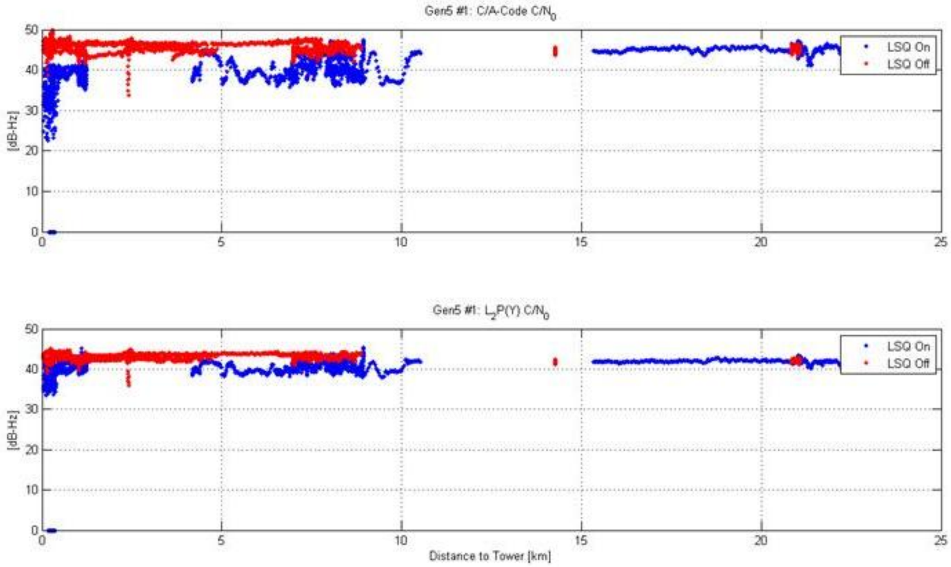
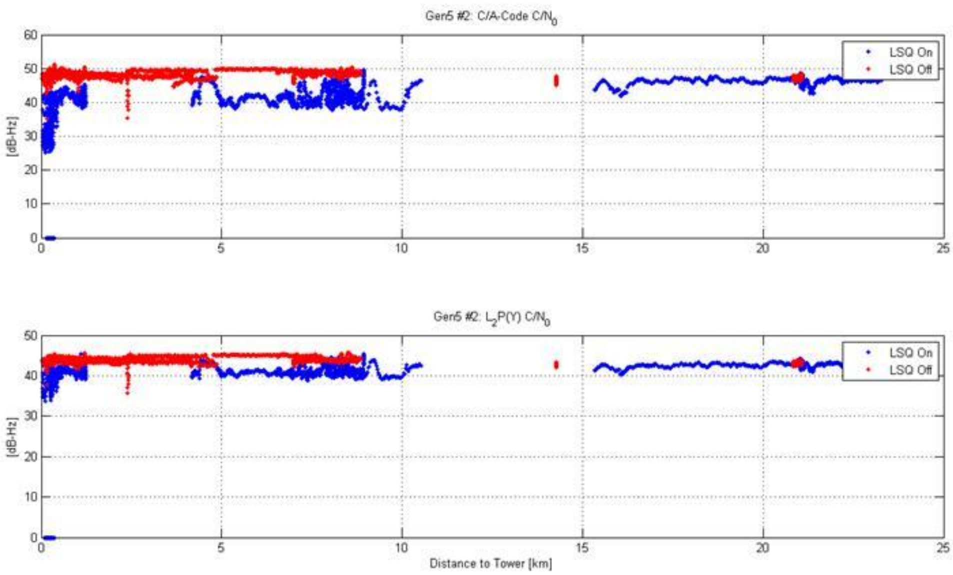


Figure 43 C/N$_0$ vs. Distance from Tower 53 for SF3000-2 Rx - 25 May 2011



Likewise the SV count vs. time plots in Figure 16 and Figure 17 show the same data gap between 11 km and 16 km as in the C/N$_0$ plots. At distances greater than 2 km there is not a large difference between the SV count with LTE on and LTE off.

Figure 44 SV Count vs. Distance from Tower 53 for SF3050 Receivers - 25 May 2011

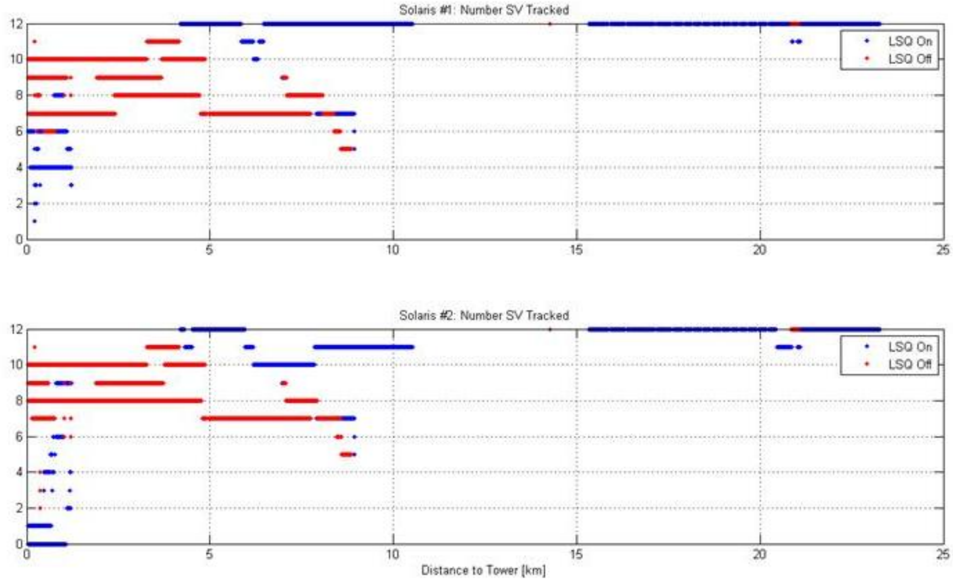
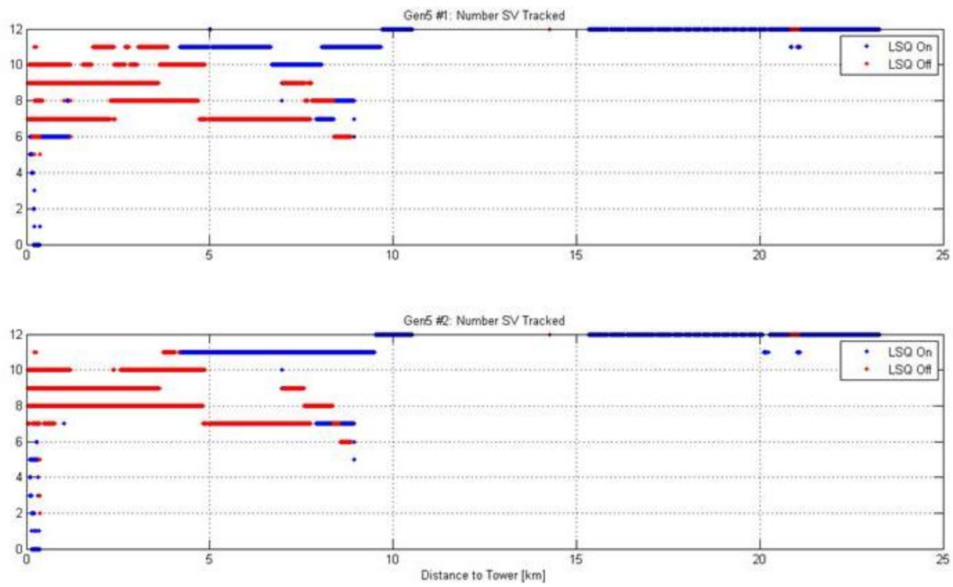


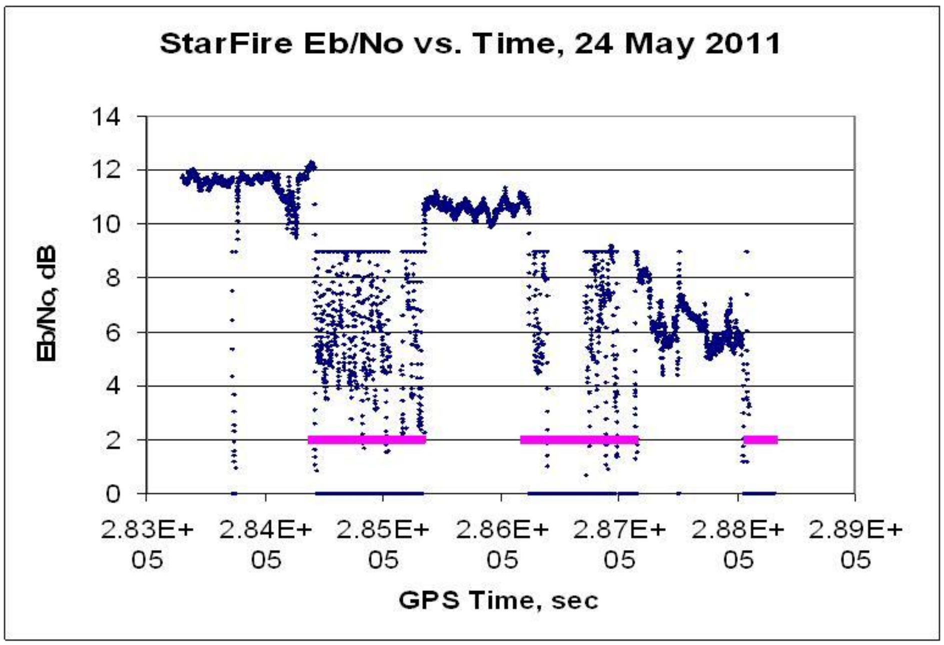
Figure 45 SV Count vs. Distance from Tower 53 for SF3000 Receivers - 25 May 2011



Rural StarFire Measurements 24 May 2011

In addition to GNSS signals, Deere transmits augmentation signals from geostationary satellites which are then received and used to enhance the accuracy of the GNSS position fix. All of the logged data from Las Vegas includes status on the received E_b/N_0 and demodulator state. The SNR of the received StarFire signal vs. time is plotted in Figure 46 over a time span of about 1 hour. The violet lines show when LTE is on. Note that when LTE is on there are numerous points at the 9 dB point but that there are also many points between 0 dB and 9 dB. This is an artifact of the E_b/N_0 filter in the demodulator, which initializes to 9 dB at the start of acquisition. In fact, no good data packets are received during the LTE on periods.

Figure 46 StarFire E_b/N_0 vs. Time, SF3000 Receiver - 24 May 2011.



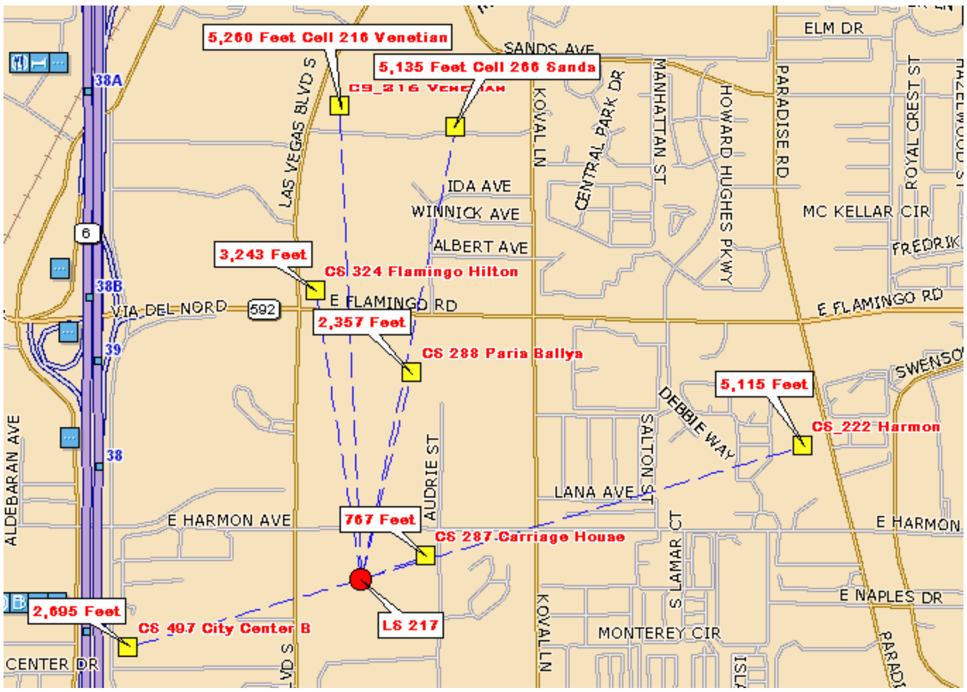
Appendix H.1.4

Verizon Wireless Live Sky Power Measurements – Las Vegas

LightSquared Sky Test Observations & NORTEL BTS GPS Receiver Status

The below map shows Verizon Wireless (VzW) Cell locations, using an existing Non-Narrow Band GPS antenna within close proximity to the LightSquared BTS identified as LS-217 (highlighted as a RED circle). When the following alarm is cleared at these sites " WARNING "GPSTM in persistent holdover // GPS entered Sustained Holdover.", the GPS receiver was not able to receive GPS timing information, and was not providing timing to the cell site equipment during the time just prior to the “Clear” Alarm Status timestamp. As detailed below, each of the VzW Cell GPS receivers cleared from a GPS Holdover alarm approximately one to two minutes after the LS-217 and LS-68 stations removed the transmitters from service.

LS-217 May 16-18



Appendix

The LightSquared test schedule and GPS Cell Alarm time stamp data " WARNING "GPSTM in persistent holdover // GPS entered Sustained Holdover." has been provided below:

		Frequency Bands to be tested		Sites to be tested			
		1526.3-1531.3 MHz LOWER BAND	1550.2-1555.2 MHz UPPER BAND				
Test Day	Date			Site #68	Site #160	Site #217	Site #53
1	5/16/2011		x	x		x	
2	5/17/2011	x	x	x		x	
3	5/18/2011	x		x		x	
4	5/19/2011		x		x		x
5	5/20/2011	x	x		x		x
6	5/21/2011	x		x		x	
7	5/22/2011		x	x	x	x	
8	5/23/2011	x		x	x	x	
9	5/24/2011	x	x		x		x
10	5/25/2011	x			x		x
11	5/26/2011	x	x	x	x	x	
12	5/27/2011	x	x				x

[21]

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"16 May 11 00:16:05"	MC800BTS1324
Clear	"16 May 11 00:16:05"	MC800BTS1324
Clear	"16 May 11 00:16:10"	MC1900BTS3287
Clear	"16 May 11 00:16:10"	MC1900BTS3287
Clear	"16 May 11 00:16:11"	MC800BTS1382
Clear	"16 May 11 00:16:11"	MC800BTS1382

Clear	"16 May 11 00:46:13"	MC800BTS1324
Clear	"16 May 11 00:46:13"	MC1900BTS3287
Clear	"16 May 11 00:46:13"	MC1900BTS3287
Clear	"16 May 11 00:46:13"	MC800BTS1324
Clear	"16 May 11 00:46:19"	MC800BTS1382
Clear	"16 May 11 00:46:19"	MC800BTS1382

Clear	"16 May 11 01:16:10"	MC800BTS1324
Clear	"16 May 11 01:16:10"	MC800BTS1324
Clear	"16 May 11 01:16:13"	MCX00BTS3497
Clear	"16 May 11 01:16:13"	MCX00BTS3497
Clear	"16 May 11 01:16:15"	MC1900BTS3287
Clear	"16 May 11 01:16:15"	MC1900BTS3287
Clear	"16 May 11 01:16:16"	MC800BTS1382
Clear	"16 May 11 01:16:16"	MC800BTS1382
Clear	"16 May 11 01:46:40"	MC800BTS1382

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"16 May 11 01:46:40"	MC800BTS1382
Clear	"16 May 11 01:46:43"	MCX00BTS3497
Clear	"16 May 11 01:46:43"	MCX00BTS3497

Clear	"16 May 11 02:16:48"	MC800BTS1324
Clear	"16 May 11 02:16:48"	MC800BTS1324
Clear	"16 May 11 02:16:51"	MCX00BTS3497
Clear	"16 May 11 02:16:51"	MCX00BTS3497
Clear	"16 May 11 02:16:53"	MC800BTS1382
Clear	"16 May 11 02:16:53"	MC800BTS1382
Clear	"16 May 11 02:20:13"	MCX00BTS2222
Clear	"16 May 11 02:20:13"	MCX00BTS2222
Clear	"16 May 11 02:20:49"	MC800BTS1216
Clear	"16 May 11 02:20:49"	MC800BTS1216

Clear	"16 May 11 02:46:51"	MC800BTS1382
Clear	"16 May 11 02:46:51"	MC800BTS1382
Clear	"16 May 11 02:46:56"	MC1900BTS3287
Clear	"16 May 11 02:46:56"	MC1900BTS3287
Clear	"16 May 11 02:46:59"	MCX00BTS3497
Clear	"16 May 11 02:46:59"	MCX00BTS3497
Clear	"16 May 11 03:16:53"	MC800BTS1382
Clear	"16 May 11 03:16:53"	MC800BTS1382
Clear	"16 May 11 03:16:58"	MC800BTS1324
Clear	"16 May 11 03:16:58"	MC800BTS1324
Clear	"16 May 11 03:16:58"	MC1900BTS3287
Clear	"16 May 11 03:16:58"	MC1900BTS3287
Clear	"16 May 11 03:17:01"	MCX00BTS3497
Clear	"16 May 11 03:17:01"	MCX00BTS3497

Clear	"16 May 11 03:46:56"	MC800BTS1382
Clear	"16 May 11 03:46:56"	MC800BTS1382
Clear	"16 May 11 03:46:59"	MCX00BTS3497
Clear	"16 May 11 03:46:59"	MCX00BTS3497
Clear	"16 May 11 03:47:01"	MC800BTS1324
Clear	"16 May 11 03:47:01"	MC800BTS1324
Clear	"16 May 11 03:47:06"	MC1900BTS3287
Clear	"16 May 11 03:47:06"	MC1900BTS3287

Clear	"16 May 11 04:17:04"	MC800BTS1382
Clear	"16 May 11 04:17:04"	MC800BTS1382
Clear	"16 May 11 04:17:07"	MCX00BTS3497
Clear	"16 May 11 04:17:07"	MCX00BTS3497

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"16 May 11 04:17:09"	MC1900BTS3287
Clear	"16 May 11 04:17:09"	MC1900BTS3287

Clear	"16 May 11 04:47:07"	MC800BTS1382
Clear	"16 May 11 04:47:07"	MC800BTS1382
Clear	"16 May 11 04:47:12"	MC1900BTS3287
Clear	"16 May 11 04:47:12"	MC800BTS1324
Clear	"16 May 11 04:47:12"	MC1900BTS3287
Clear	"16 May 11 04:47:12"	MC800BTS1324
Clear	"16 May 11 04:47:15"	MCX00BTS3497
Clear	"16 May 11 04:47:15"	MCX00BTS3497
Clear	"16 May 11 04:48:21"	MC800BTS1266
Clear	"16 May 11 04:48:21"	MC800BTS1266

Clear	"16 May 11 05:17:10"	MC800BTS1382
Clear	"16 May 11 05:17:10"	MC800BTS1382
Clear	"16 May 11 05:17:12"	MCX00BTS3497
Clear	"16 May 11 05:17:12"	MCX00BTS3497
Clear	"16 May 11 05:17:19"	MC1900BTS3287
Clear	"16 May 11 05:17:19"	MC1900BTS3287

Clear	"16 May 11 05:41:52"	MC800BTS1216
Clear	"16 May 11 05:41:52"	MC800BTS1216
Clear	"16 May 11 05:45:23	MCX00BTS3216
Clear	"16 May 11 05:45:23	MCX00BTS3216
Clear	"16 May 11 05:47:18"	MC800BTS1382
Clear	"16 May 11 05:47:18"	MC800BTS1382
Clear	"16 May 11 05:47:22"	MC800BTS1324
Clear	"16 May 11 05:47:22"	MC800BTS1324
Clear	"16 May 11 05:47:22"	MC1900BTS3287
Clear	"16 May 11 05:47:22"	MC1900BTS3287
Clear	"16 May 11 05:47:26"	MCX00BTS3497
Clear	"16 May 11 05:47:26"	MCX00BTS3497

Clear	"17 May 11 02:16:29"	MCX00BTS2222
Clear	"17 May 11 02:16:29"	MCX00BTS2222

Clear	"17 May 11 04:46:23"	MC800BTS1266
Clear	"17 May 11 04:46:23"	MC800BTS1266

Clear	"17 May 11 05:37:52"	MC800BTS1216
Clear	"17 May 11 05:37:52"	MC800BTS1216

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"18 May 11 00:16:42"	MC800BTS1324
Clear	"18 May 11 00:16:42"	MC800BTS1324
Clear	"18 May 11 00:16:43"	MC800BTS1382
Clear	"18 May 11 00:16:43"	MC800BTS1382
Clear	"18 May 11 00:16:45"	MCX00BTS3497
Clear	"18 May 11 00:16:45"	MCX00BTS3497
Clear	"18 May 11 00:16:47"	MC1900BTS3287
Clear	"18 May 11 00:16:47"	MC1900BTS3287

Clear	"18 May 11 00:46:06"	MCX00BTS3497
Clear	"18 May 11 00:46:06"	MCX00BTS3497
Clear	"18 May 11 00:46:08"	MC800BTS1382
Clear	"18 May 11 00:46:08"	MC800BTS1324
Clear	"18 May 11 00:46:08"	MC800BTS1382
Clear	"18 May 11 00:46:08"	MC800BTS1324
Clear	"18 May 11 00:46:22"	MC1900BTS3288
Clear	"18 May 11 00:46:22"	MC1900BTS3288
Clear	"18 May 11 00:46:34"	MC1900BTS3287
Clear	"18 May 11 00:46:34"	MC1900BTS3287

Clear	"18 May 11 01:16:32"	MC800BTS1382
Clear	"18 May 11 01:16:32"	MC800BTS1382

Clear	"18 May 11 01:46:40"	MC800BTS1324
Clear	"18 May 11 01:46:40"	MC800BTS1324
Clear	"18 May 11 01:46:45"	MC1900BTS3287
Clear	"18 May 11 01:46:45"	MC1900BTS3287

Clear	"18 May 11 02:11:56"	MC800BTS1216
Clear	"18 May 11 02:11:56"	MC800BTS1216
Clear	"18 May 11 02:12:29"	MCX00BTS2222
Clear	"18 May 11 02:12:29"	MCX00BTS2222
Clear	"18 May 11 02:16:47"	MC1900BTS3287
Clear	"18 May 11 02:16:47"	MC1900BTS3287

Clear	"18 May 11 02:46:28"	MC800BTS1382
Clear	"18 May 11 02:46:28"	MC800BTS1382
Clear	"18 May 11 02:46:46"	MCX00BTS3497
Clear	"18 May 11 02:46:46"	MCX00BTS3497
Clear	"18 May 11 02:46:47"	MC1900BTS3288
Clear	"18 May 11 02:46:48"	MC1900BTS3287
Clear	"18 May 11 02:46:48"	MC1900BTS3287

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"18 May 11 03:16:49"	MC1900BTS3288
Clear	"18 May 11 03:16:49"	MC1900BTS3288
Clear	"18 May 11 03:16:51"	MC800BTS1324
Clear	"18 May 11 03:16:51"	MC800BTS1324
Clear	"18 May 11 03:16:51"	MC800BTS1382
Clear	"18 May 11 03:16:51"	MC800BTS1382
Clear	"18 May 11 03:16:56"	MC1900BTS3287
Clear	"18 May 11 03:16:56"	MC1900BTS3287

Clear	"18 May 11 03:46:56"	MC800BTS1324
Clear	"18 May 11 03:46:56"	MC800BTS1382
Clear	"18 May 11 03:46:56"	MC800BTS1324
Clear	"18 May 11 03:46:56"	MC800BTS1382
Clear	"18 May 11 03:47:01"	MC1900BTS3287
Clear	"18 May 11 03:47:01"	MC1900BTS3287

Clear	"18 May 11 04:16:59"	MC800BTS1382
Clear	"18 May 11 04:16:59"	MC800BTS1382
Clear	"18 May 11 04:17:02"	MC1900BTS3288
Clear	"18 May 11 04:17:02"	MC1900BTS3288
Clear	"18 May 11 04:17:03"	MC1900BTS3287
Clear	"18 May 11 04:17:03"	MC1900BTS3287
Clear	"18 May 11 04:17:04"	MC800BTS1324
Clear	"18 May 11 04:17:04"	MC800BTS1324
Clear	"18 May 11 04:17:17"	MCX00BTS3497
Clear	"18 May 11 04:17:17"	MCX00BTS3497

Clear	"18 May 11 04:42:17"	MC800BTS1266
Clear	"18 May 11 04:42:17"	MC800BTS1266
Clear	"18 May 11 04:47:02"	MC800BTS1382
Clear	"18 May 11 04:47:02"	MC800BTS1382
Clear	"18 May 11 04:47:05"	MC1900BTS3288
Clear	"18 May 11 04:47:05"	MC1900BTS3288
Clear	"18 May 11 04:47:06"	MC800BTS1324
Clear	"18 May 11 04:47:06"	MC800BTS1324
Clear	"18 May 11 04:47:10"	MCX00BTS3497
Clear	"18 May 11 04:47:10"	MCX00BTS3497
Clear	"18 May 11 04:47:12"	MC1900BTS3287
Clear	"18 May 11 05:17:09"	MC800BTS1382
Clear	"18 May 11 05:17:09"	MC800BTS1382
Clear	"18 May 11 05:17:12"	MCX00BTS3497
Clear	"18 May 11 05:17:12"	MCX00BTS3497
Clear	"18 May 11 05:17:13"	MC1900BTS3288

Alarm Status	Time Stamp NORTEL BTS	Last Three Digits (Cell ID)
Clear	"18 May 11 05:17:13"	MC1900BTS3288
Clear	"18 May 11 05:17:14"	MC1900BTS3287
Clear	"18 May 11 05:17:14"	MC1900BTS3287

Clear	"18 May 11 05:34:51"	MC800BTS1216
Clear	"18 May 11 05:34:51"	MC800BTS1216
Clear	"18 May 11 05:34:53	MCX00BTS3216
Clear	"18 May 11 05:34:53	MCX00BTS3216

Clear	"18 May 11 05:47:15"	MCX00BTS3497
Clear	"18 May 11 05:47:15"	MCX00BTS3497
Clear	"18 May 11 05:47:17"	MC800BTS1324
Clear	"18 May 11 05:47:17"	MC800BTS1324
Clear	"18 May 11 05:47:17"	MC1900BTS3287
Clear	"18 May 11 05:47:17"	MC1900BTS3287

Summary:

Similar GPS alarms were experienced during the following dates highlighted below, May 21-22, and May 26 which tracked very closely to the LightSquared Transmitter On/Off cycle as documented within the Sky Test Plan. However, May 23rd did not track as consistent as the above mentioned dates.

Additionally, the Carriage House cell (CS-287) did not trigger any GPS alarms on the NOTEL BTS platform since the GPS antenna was upgraded on May 19, 2011 to the Narrow Band GPS Antenna solution.

		Frequency Bands to be tested		Sites to be tested			
Test Day	Date	1526.3-1531.3 MHz LOWER BAND	1550.2-1555.2 MHz UPPER BAND	Site #68	Site #160	Site #217	Site #53
1	5/16/2011		x	x		x	
2	5/17/2011	x	x	x		x	
3	5/18/2011	x		x		x	
4	5/19/2011		x		x		x
5	5/20/2011	x	x		x		x
6	5/21/2011	x		x		x	
7	5/22/2011		x	x	x	x	
8	5/23/2011	x		x	x	x	
9	5/24/2011	x	x		x		x
10	5/25/2011	x			x		x
11	5/26/2011	x	x	x	x	x	
12	5/27/2011	x	x				x

Appendix H.1.5

NOAA/NGS Live Sky Test Results – Las Vegas

NOAA Live Sky Test Results 1

Las Vegas, Nevada 2

May 19 -20, 2011 3

The NOAA / National Geodetic Survey participated in the LightSquared sponsored Live 5 Sky testing in Las Vegas, May 19 -20, 2011. The NOAA vehicle was configured with 6 six high precision geodetic / survey GPS receivers connected through an eight way 7 splitter to a geodetic antenna using magnetic mounts on the vehicle roof. A single survey 8 receiver with another geodetic antenna was separately fixed to the vehicle roof also using 9 magnetic mounts. To maintain receiver anonymity in presenting the results, random 10 codes were assigned to the geodetic/ survey receivers tested. These codes were obtained 11 from the LightSquared / United States GPS Industry Council (USGIC) Technical 12 Working Group (TWG) facilitator and will be used to report the NOAA results.

Table 1

LightSquared Site ID	Latitude	Longitude	Antenna Height AGL (ft)	Number of Sectors	Azimuths (degrees)	City
LVGS0053-C1	35.9697	-114.8681	60	2	30, 270	Rural
LVGS0068-C1	36.1245	-115.2244	55	3	0, 120 ,240	Suburban
LVGS0160-C1	36.127	-115.189	50	3	0, 120, 240	Urban
LVGS0217-C1	36.1065	-115.1705	235	2	0, 240	Dense Urban

The NOAA tests were primarily focused on testing at Rural Site LVGS0053-C1 (Site 53). Some data was also taken at the other sites, but the results were not processed as the geodetic / survey receivers would generally not be used in obstructed environments for high precision applications. The transmission logs for May 19 for Site 53 are shown below in Table 2. On this day the LightSquared Ancillary Terrestrial Component (ATC) reference station was transmitting on the upper high 5MHz band at a center frequency of 1552.7 MHz. The transmit power per sector was set at 62 dBm for the first transmission between 12:00 and 12:15 AM (local time) and then decreased to 59 dBm per sector for the remaining transmission times. Site 53 was transmitting on two sectors at azimuths 30^{0} and 270^{0}.

A typical vehicle test run from west to east around Site 53 is shown in Figure 1 with some tracking loss 22 to 93 m. near the transmitter site. The general test procedure was to position the vehicle within several hundred meters north or slightly northwest of Site 53 and wait for the ATC transmissions to start. Once the LightSquared transmitter was enabled most GPS receivers lost tracking within a very short time that near to the transmitter. The vehicle would then drive west or east until all GPS receivers resumed tracking and then turn around and approach the transmitter site until loss of tracking again occurred. A more severe tracking loss in the west direction for one of the seven GPS receivers is shown in Figure 2. The NOAA vehicle participated in the testing at Site 53 during the first four transmissions between 12:00 am and 1:45 am on May 19. The test results are summarized in Tables 3-7 and note the tracking loss in a data set (900 data points in 15 minutes with a one second data rate) as a percentage and the tracking loss distance from the transmitter site. Table 8 lists the maximum distance tracking loss measured for each receiver in the east and west direction.

Figure 1. Typical East –West NOAA Vehicle Test Track May 19 -20, 2011

Table 2. LightSquared Transmission Times

Date	Site	Channels	Time (Local PDT)	Site Operator	EIRP (dBm)/Sector
5/19/2011	053	Upper 5 MHz (CF= 1552.7 MHz)	12:00:00 AM	Turn on site	62
			12:15:00 AM	Turn off site	
			12:30:00 AM	Turn on site	59
			12:45:00 AM	Turn off site	
			1:00:00 AM	Turn on site	59
			1:15:00 AM	Turn off site	
			1:30:00 AM	Turn on site	59
			1:45:00 AM	Turn off site	

Figure 2. Tracking Loss Receiver H33451 Site 53 May 19, 2011

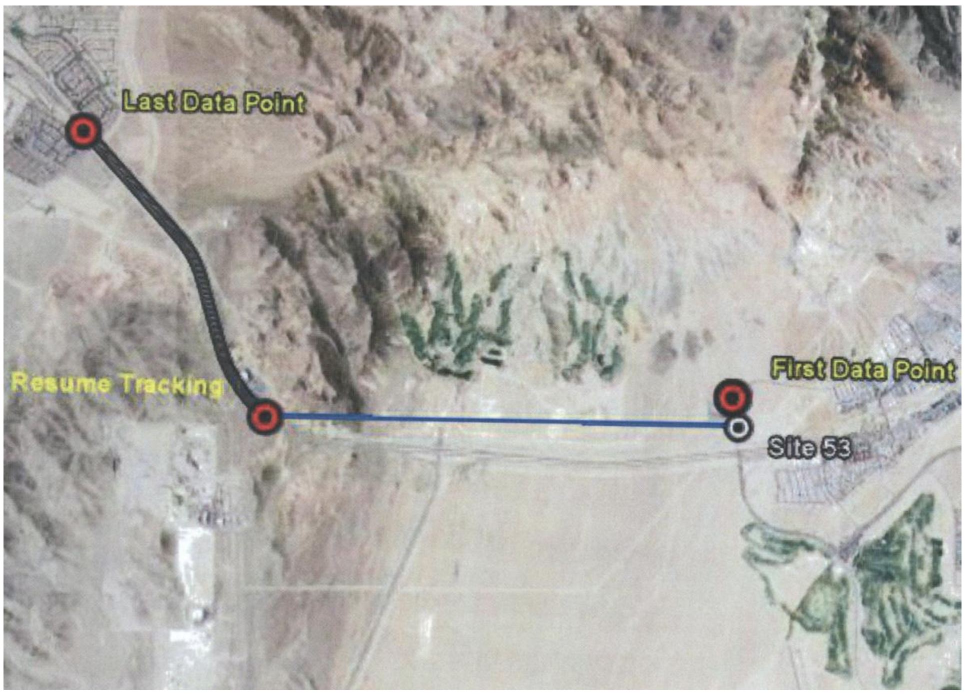


Table 3. Receiver H07007 Tracking Loss May 19 (Day 139)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H07007 w/ Antenna 2	May 19,2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase 0 Deployment	47.7 %	Tracking Loss Distance west side of Site 53 Resume @ 191 m. 300 m. to 1189 m.	Tracking Loss Distance east side of Site 53
H07007 w/ Antenna 2	May 19,2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	61.1 %	Tracking Loss Distance west side of Site 53 to 184 m. from 73 m.	Tracking Loss Distance east side of Site 53 from 809 m. to 1017 m.
H07007 w/ Antenna 2	May 19,2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	74.8 %	Tracking Loss Distance west side of Site 53 from 34 m.	Tracking Loss Distance east side of Site 53 to 1101 m. from 693 m. to 228 m.
H07007 w/ Antenna 2	May 19,2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	33.2%	Tracking Loss Distance west side of Site 53 from 77 m. from 288 m. to 1433 m. from 1115 m. to 248 m. from 290 m. to 1339 m.	Tracking Loss Distance east side of Site 53 to 484 m.

Table 4. Receiver H41591 Tracking Loss May 19 (Day 139)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H41591 w/ Antenna 5	May 19, 2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase 0 Deployment	43.6 %	Tracking Loss Distance west side of Site 53 116 m. to 184 m. driving south 360 m. to 1303 m.	Tracking Loss Distance east side of Site 53
H41591 w/ Antenna 5	May 19, 2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	28.2 %	Tracking Loss Distance west side of Site 53 intermittent tracking 67 m.	Tracking Loss Distance east side of Site 53 to 764 m.
H41591 w/ Antenna 5	May 19, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	60.2 %	Tracking Loss Distance west side of Site 53 from 35 m. intermittent tracking from 37 m. to 138 m.	Tracking Loss Distance east side of Site 53 to 1025 m.
H41591 w/ Antenna 5	May 19, 2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	5.4 %	Tracking Loss Distance west side of Site 53 from 35 m. to 199 m.	Tracking Loss Distance east side of Site 53

Table 5. Receiver H80708 Tracking Loss May 19 (Day 139)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53	Distance to Site 53
H80708 w/ Antenna 5	May 19,2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase 0 Deployment	21%	Tracking Loss Distance west side of Site 53 103 m. to 264 m. - west 775 m. to 195 m. – east & south	Tracking Loss Distance east side of Site 53
H80708 w/ Antenna 5	May 19,2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	0%	No Tracking Loss	No Tracking Loss

Table 6. Receiver H33451 Tracking Loss May 19 (Day 139)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H33451 w/ antenna 5	May 19,2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase 0 Deployment	80.4 %	Tracking Loss Distance -west side of site 53 from 242 m. to 3753 m.	Tracking Loss Distance –east side of site 53
H33451 w/ antenna 5	May 19,2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	74.1 %	Tracking Loss Distance -west side of site 53 from 90 m. to 182 m. m. – driving south	Tracking Loss Distance –east side of site 53
H33451 w/ antenna 5	May 19,2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	89.8%	Tracking Loss Distance -west side of site 53 from 39 m.	Tracking Loss Distance –east side of site 53 to 1003 m. from 1165 m. to 1125 m. driving north
H33451 w/ antenna 5	May 19,2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	65.9%	Tracking Loss Distance -west side of site 53 from 148 m. to 237 m. intermittent tracking from 237 m. to 2222 m. from 1432 m. to 2290m. m.	Tracking Loss Distance –east side of site 53 to 1109 m. from 553 m. intermittent tracking

Table 7. Receiver H84576 Tracking Loss May 19 (Day 139)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H84576 w/ Antenna 5	May 19,2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase 0 Deployment	68.7 %	Tracking Loss Distance west side of Site 53 from 231 m. to 3995 m.	Tracking Loss Distance east side of Site 53
H84576 w/ Antenna 5	May 19,2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	83.8 %	Tracking Loss Distance west side of Site 53 from 86 m. to 173 m.	Tracking Loss Distance east side of Site 53 to 1821 m. from 843 m.
H84576 w/ Antenna 5	May 19,2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	95.6 %	Tracking Loss Distance west side of Site 53 from 40m. – No data tracking resumed	Tracking Loss Distance east side of Site 53
H84576 w/ Antenna 5	May 19,2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase 0 Deployment	89.8%	Tracking Loss Distance west side of Site 53 from 94 m.	Tracking Loss Distance east side of Site 53 to 2012 m.

Table 8. Maximum Tracking Loss Distances, May 19, 2011

Receiver ID	Tracking Loss Range - East	Tracking Loss Range - West
H07007 w/ Antenna 2	1101 m.	1339 m.
H41591 w/ Antenna 5	1025 m.	1303 m.
H80708 w/ Antenna 5	No Tracking Loss	775 m.
H33451 w/ Antenna 5	1125 m.	3753 m.
H84576 w/ Antenna 5	2012 m.	3995 m.

Receiver H80708 only logged two data sessions on May 19th that were converted to the Rinex format. No additional data was logged for the remainder of the testing. Receivers H47596 and H91389 logged error messages during the conversion to Rinex format and the binary data for May 19 could not be recovered. These receivers operated properly on May 20.

The test results for May 20th are summarized in Tables 3-7 and note the tracking loss in a data set as a percentage and the tracking loss distance from the transmitter site. Table 17 lists the maximum distance tracking loss measured for each receiver in the east and west direction. The transmission log for May 20 for Site 53 is shown below in Table 9.

Table 9. LightSquared Transmission Times

Date	Site	Channels	Time (Local PDT)	Site Operator	EIRP (dBm) / Sector
5/20/2011	**053**	**Lower 5 MHz (CF= 1528.8 MHz) & Upper 5 MHz (CF= 1552.7 MHz)**	12:00:00 AM	Turn on site	62
			12:15:00 AM	Turn off site	
			12:30:00 AM	Turn on site	59
			12:45:00 AM	Turn off site	
			1:00:00 AM	Turn on site	59
			1:15:00 AM	Turn off site	
			1:30:00 AM	Turn on site	59
			1:45:00 AM	Turn off site	
			2:00:00 AM	Turn on site	59
			2:15:00 AM	Turn off site	
			2:30:00 AM	Turn on site	59
			2:45:00 AM	Turn off site	

Table 10. Receiver H07007 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H07007 w/ Antenna 1	May 20,2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase I Deployment	6.3 %	Tracking Loss Distance west side of Site 53 from 283 m. to 83 m.	Tracking Loss Distance east side of Site 53
H07007 w/ Antenna 1	May 20,2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	3.6 %	No tracking loss	No tracking loss
H07007 w/ Antenna 1	May 20,2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	4.8 %	Tracking Loss Distance west side of Site 53 22 to 93 m.	Tracking Loss Distance east side of Site 53
H07007 w/ Antenna 1	May 20,2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	2.1 %	Tracking Loss Distance west side of Site 53 from 60 m. to 75m. – driving south	Tracking Loss Distance east side of Site 53 from 455 m. to 520 m.
H07007 w/ Antenna 1	May 20,2011 2:00 – 2:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	9.3 %	Tracking Loss Distance west side of Site 53 from 213 m. to 87 m. east & south from 105 m. to 362 m.	Tracking Loss Distance east side of Site 53
H07007 w/ Antenna 1	May 20,2011 2:30 – 2:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	0.4 %	No tracking loss	No tracking loss

Table 11. Receiver H41591 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H41591 w/ Antenna 1	May 20, 2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase I Deployment	81.2 %	Tracking Loss Distance west side of Site 53 from 763 m.	Tracking Loss Distance east side of Site 53 to 1868 m.
H41591 w/ Antenna 1	May 20, 2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	76.3 %	Tracking Loss Distance west side of Site 53 to 2981 m.	Tracking Loss Distance east side of Site 53 from 881 m.
H41591 w/ Antenna 1	May 20, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	73.2 %	Tracking Loss Distance west side of Site 53 from 761 m. to 2255 m. from 2116 m.	Tracking Loss Distance east side of Site 53 to 1118 m. from 1130 m. to 1418 m.
H41591 w/ Antenna 1	May 20,2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	85.4 %	Tracking Loss Distance west side of Site 53 from 761 m. to 2255 m. from 2116 m.	Tracking Loss Distance east side of Site 53 to 1118 m. from 1130 m. to 1418 m.
H41591 w/ Antenna 1	May 20,2011 2:00 – 2:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	75.1 %	Tracking Loss Distance west side of Site 53 from 231 m. to 2344 m. from 2138 m.	Tracking Loss Distance east side of Site 53 to 1202 m. from 1233 m. to intermittent tracking at 957 m.
H41591 w/ Antenna 1	May 20,2011 2:30 – 2:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	99.2 %	Tracking Loss Distance west side of Site 53 from 311 m. to 1162 m. to 2328 m.	Tracking Loss Distance east side of Site 53 from 311 m. to 1162 m. from 1156 m.

Table 12. Receiver H33451 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H33451 w/ antenna 1	May 20, 2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase I Deployment	83.1 %	Tracking Loss Distance -west side of site 53 from 808 m.	Tracking Loss Distance –east side of site 53 to 1854 m.
H33451 w/ antenna 1	May 20, 2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	76.6 %	Tracking Loss Distance -west side of site 53 to 3133 m. from 2481 m.	Tracking Loss Distance –east side of site 53 from 879 to 1114 m.
H33451 w/ antenna 1	May 20, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	78.8%	Tracking Loss Distance -west side of site 53 from 783 m. to 2424 m. from 2167 m.	Tracking Loss Distance –east side of site 53 to 1886 m.
H33451 w/ antenna 1	1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	87.4 %	Tracking Loss Distance -west side of site 53 from 238 m.	Tracking Loss Distance –east side of site 53 to 1886 m. from 1932 m. to 1998 m. – intermittent tracking
H33451 w/ antenna 1	May 20, 2011 2:00 – 2:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	74.7 %	Tracking Loss Distance -west side of site 53 from 235 m. to 2375 m. from 2411 m. to 2423 m. from 2101 m. to 578 m. intermittent tracking / test ends	Tracking Loss Distance –east side of site 53 to 1202 m. from 1255 m.
H33451 w/ antenna 1	May 20, 2011 2:30 – 2:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	85.9 %	Tracking Loss Distance -west side of site 53 to 2263 m. from 2140 m.	Tracking Loss Distance –east side of site 53 from 309 m. to 1185 m. from 1168 m. to 682 m. south Intermittent tracking from 682 m. to 397 m. / test ends

Table 13. Receiver H47596 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H47596 w/ antenna 1	May 20, 2011 / 12:00 – 12:15 AM / LightSquared Transmitter 62 dBm per sector Phase 1 Deployment	84.8%	Tracking Loss Distance -west side of site 53 from 768 m.	Tracking Loss Distance –east side of site 53 to 1099 m. from 1120 m. to 2018 m.
H91389 w/ antenna 1	May 20, 2011 / 12:30 – 12:45 AM	No Data - File Overwritten		
H91389 w/ antenna 1	May 20, 2011 / 1:00 – 1:15 AM LightSquared Transmitter / 59 dBm per sector Phase I Deployment	64.5 %	Tracking Loss Distance -west side of site 53 from 769 m. to 2116 m. from 2051 m.	Tracking Loss Distance –east side of site 53 to 1110 m. from 1144 m. to 1153 m. from 1041 m. to 1202 m.
H91389 w/ antenna 1	May 20, 2011 / 1:30 – 1:45 AM LightSquared Transmitter / 59 dBm per sector Phase I Deployment	81.2 %	Tracking Loss Distance -west side of site 53 from 213 m. to 385 m – driving south from 286 m.	Tracking Loss Distance –east side of site 53 to 1132 m. from 1113 m. to 1591 m.
H91389 w/ antenna 1	May 20, 2011 / 2:00 – 2:15 AM LightSquared Transmitter / 59 dBm per sector Phase I Deployment	63.3 %	Tracking Loss Distance -west side of site 53 from 237 m. to 1904 m. from 2052 m	Tracking Loss Distance –east side of site 53 to 1200 m. from 1112 m. to 653 m. – Intermittent tracking
H91389 w/ antenna 1	May 20, 2011 / 2:30 – 2:45 AM LightSquared Transmitter / 59 dBm per sector Phase I Deployment	71.5 %	Tracking Loss Distance -west side of site 53 to 2094 m. from 2075 m. to 329 m. 295 m. to 197m. south of Site 53 from 151 m.-	Tracking Loss Distance –east side of site 53 from 313 m. to 1104 m. from 1030 m. 1103 m.

Table 14. Receiver H91389 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H91389 w/ antenna 1	May 20, 2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase I Deployment	85 %	Tracking Loss Distance -west side of Site 53 from 764 m.	Tracking Loss Distance -east side of Site 53 to 1112 m. 1166m. to 2027 m.
H91389 w/ antenna 1	May 20, 2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	No Data Receiver Data File Overwritten		
H91389 w/ antenna 1	May 20, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	64.6 % Tracking Loss Distance - west side	of Site 53 from 769 m. to 2119 m. 2052m. to 1668 m. from 1602 m.	Tracking Loss Distance -east side of Site 53 to 1136m. 1124m. to 1141m. from 1043 m. to 1201m.
H91389 w/ antenna 1	May 20, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	64.6 %	Tracking Loss Distance -west side of Site 53 215 m. to 381 m. 407 m. to 516 m. from 283 m.	Tracking Loss Distance -east side of Site 53 to 1113 m. 1102 m. to 1586 m. 1490 m. to 1466 m. 1231 m. to 1185 m.
H91389 w/ antenna 1	May 20, 2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	70.1 %	Tracking Loss Distance -west side of Site 53 215 m. to 381 m. 407 m. to 516 m. from 283 m.	Tracking Loss Distance -east side of Site 53 to 1113 m. 1102 m. to 1586 m. 1490 m. to 1466 m.
H91389 w/ antenna 1	May 20, 2011 2:00 – 2:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	63.3 %	Tracking Loss Distance -west side of Site 53 Resume tracking @1901 m. from 2052 m.	Tracking Loss Distance -east side of Site 53 to 1203 m. 1124 m. to 1069 m. 881 m. to 865 m. 711 m. to 657 m.
H91389 w/ antenna 1	May 20, 2011 2:30 – 2:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	71.5 %	Tracking Loss Distance -west side of Site 53 Resume tracking @1101 m. to 2098 m. from 2075 m. 402 m. to 508 m. 293 m. to 197m. from 154 m.	Tracking Loss Distance -east side of Site 53 1130 m. to 1144 m. from 1026 m. to 328 m. to 1099 m. 108

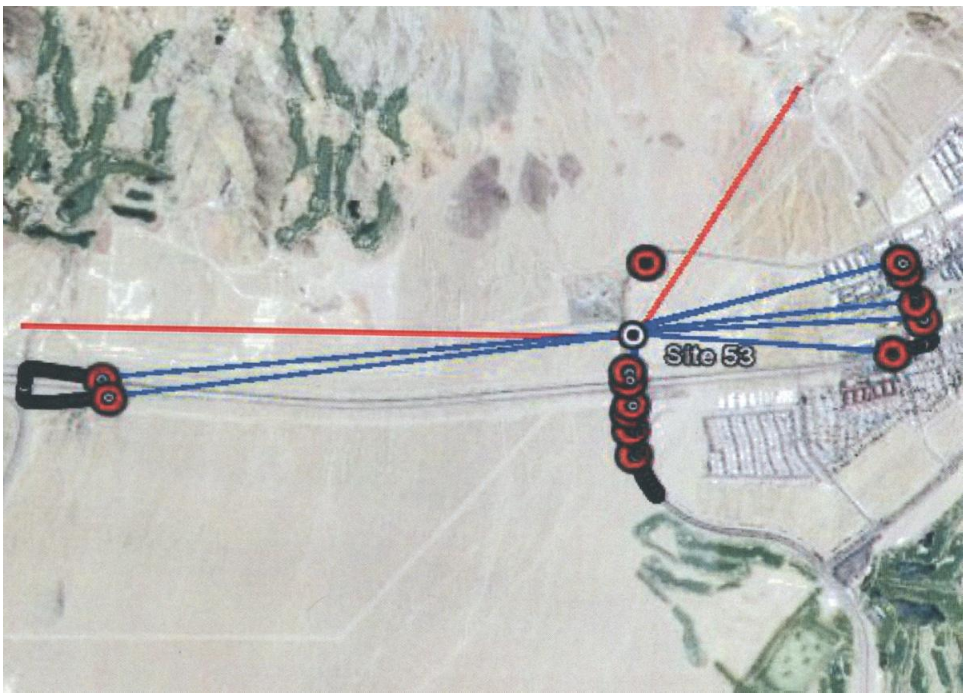
Table 15. Receiver H84576 Tracking Loss May 20 (Day 140)

Receiver ID	Transmit Time Local (GPS-7)	Percent Tracking Loss During Transmit Time	Distance to Site 53 Transmitter	Distance to Site 53 Transmitter
H84576 w/ Antenna 1	May 20, 2011 12:00 – 12:15 AM LightSquared Transmitter 62 dBm per sector Phase I Deployment	88.4 %	Tracking Loss Distance west side of Site 53 from 762 m.	Tracking Loss Distance east side of Site 53 to 2015 m.
H84576 w/ Antenna 1	May 20, 2011 12:30 – 12:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	77.1 %	Tracking Loss Distance west side of Site 53 to 3151 m. from 2506 m. to 759 m.	Tracking Loss Distance east side of Site 53 from 885 m.
H84576 w/ Antenna 1	May 20, 2011 1:00 – 1:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	76.9 %	Tracking Loss Distance west side of Site 53 from 772 m. to 2304 m. from 2140 m.	Tracking Loss Distance east side of Site 53 to 1637 m.
H84576 w/ Antenna 1	May 20, 2011 1:30 – 1:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	98 %	Tracking Loss Distance west side of Site 53 233m. –Last Data Pt.	Tracking Loss Distance east side of Site 53
H84576 w/ Antenna 1	May 20, 2011 2:00 – 2:15 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	80.2 %	Tracking Loss Distance west side of Site 53 from 234 m. to 2365 m. from 2179 m.	Tracking Loss Distance east side of Site 53 to 1198 m. Intermittent tracking 1337 m. to 745 m.
H84576 w/ Antenna 1	May 20, 2011 2:30 – 2:45 AM LightSquared Transmitter 59 dBm per sector Phase I Deployment	91.2 %	Tracking Loss Distance west side of Site 53 310 m. to 1113 m. to 2359 m.	Tracking Loss Distance east side of Site 53 from 1124 m.

Table 16. Maximum Tracking Loss Distances, May 20, 2011

Receiver ID	Tracking Loss Range - East	Tracking Loss Range - West
H07007 w/ Antenna 5	520 m.	362 m.
H41591 w/ Antenna 1	1868 m.	2981 m.
H33451 w/ Antenna 1	1886 m.	3133 m.
H84576 w/ Antenna 1	2015 m.	3151 m.
H47596 w/ Antenna 1	1153 m.	2094 m.
H91389 w/ Antenna 1	2027 m.	2119 m.

Figure 3. Site 53 LightSquared Transmitting Sectors @ 30^0 and 270^0 Summary Analysis and Conclusions



The geodetic antenna used in combination with the high precision receiver determines the receiver response to adjacent band interference and in some cases results in a significant reduction in tracking loss. Receiver H07007 connected to geodetic antenna 2 as a standalone unit logged tracking loss percentages between 33 – 75 % during the first day 16 of NOAA testing on May 19. On the second day of testing this same receiver was connected to geodetic antenna 5 and showed a dramatic decrease in data tracking loss percentages from no loss (0.4%) to 9.3% compared the first day. The tracking loss range also decreased from 1109 – 1339 m. on the first day to 362-520 m. on the second day. Receiver H07007 also had one test session with no tracking loss in either the east or west quadrant which did not occur on May 19. The tracking loss ranges were always larger in the western quadrant than in the eastern region. Figure 3 plots the LightSquared sectors for a given test run. The tracking loss ranges are greater in the west as the main sector beam at 270$_0$ is closer to the road taken by the NOAA vehicle. Tracking losses occurred in most cases as the vehicle crossed the 30$_0$ main sector beam in the eastern quadrant, but tracking resumed at shorter ranges due to less power detected by the receiver further away from the sector 30° boresight.

Appendix H.1.6

High Precision and Timing Test Plan

Precision and TimingReceiver LightSquared L-Band LTE RFI Test PLAN

Revision History

REV	Date	Editor	DESCRIPTION
B	3/22/2011	P. Fenton	Initial Draft
C	3/25/2011	P. Fenton	Incorporating initial feedback
D	4/4/2011	P. Galyean	Incorporating result of first Sub-Team meeting
E	4/6/11	P. Galyean	Incorporating results of second Sub-Team meeting
F	4/7/11	P. Fenton	Incorporating homework
G	4/7/11	P. Fenton	Incorporating results of second Timing Team meeting
H	4/7/11	P. Galyean	Incorporating homework
I	4/8/11	P. Galyean	Revisions per Sub-Team meetings
J	4/18/11	P. Galyean	Revisions per Sub-Team meetings
K	5/5/11	P. Galyean	Revisions per Spirent automation discussions
L	5/6/11	P. Galyean	Revisions per Spirent automation discussions
M	5/7/11	P. Galyean	Fix art problem
N	5/16/11	P. Galyean	Final revisions

CONTENT

List of Figures

Purpose

This document outlines the test setup and test procedure to evaluate Timing and High Precision GNSS receiver performance when the LightSquared L-band LTE signals are present.

Basic Assumptions

The following assumptions control certain aspects of this Test Plan.

1. All testing must be completed by 5/31/2011.
2. Testing must be controlled and executed by a laboratory independent of LightSquared and of USGIC and its members.
3. All testing must be transparent, i.e., the testing can be observed by the concerned parties.
4. The test data must be recorded and available to all appropriate parties, in accordance with overall TWG agreements. The test results must be made publicly available in a consolidated form with coding that does not disclose the identity of individual receivers.
5. We expect the processing of the raw data into performance data to be done by the manufacturers, with LightSquared as observers if LightSquared desires.
6. Anechoic chamber testing must be done, and open air testing will be done if possible.
7. The selection of receivers to be tested must represent the installed base as well as current production receivers, and must represent critical applications.
8. It will be necessary to test multiple receivers at one time (preferably all at once).
9. Testing over temperature is not required, and can be at ambient temperature.
10. It is necessary to characterize and record the effects on receiver performance as observed by users of the receivers as well as the internal metrics of the receivers.
11. Testing of LightSquared handsets (or functionally similar replicas) is to be done, but the emphasis will be on testing interference from LightSquared base stations.
12. Testing of receivers must range broadly over the population, and not be restricted to “obvious” receivers.
13. Glonass will not be radiated in the chamber tests.
14. We don’t plan to deal with process variations for a given receiver type. There are enough receivers of various types that having an abnormal receiver won’t affect the conclusions, and will probably be detected in any event.
15. Testing of a handset in the chamber will be done as one of the LTE modes, not in combination with the base station testing.

Test Scenarios

High Precision Receivers – Anechoic Chamber Testing

High precision receivers have multiple modes, depending on the particular receiver, which must be tested. These include:

1. Autonomous (stand alone)
2. RTK
3. Augmentation (OmniSTAR, StarFire)

For RTK testing, there are four sub-cases to consider:

1. The Rover and Base both experience interference.
2. The Rover experiences interference and the Base does not.
3. The Base experiences interference and the Rover does not.
4. The Rover and Base both do not experience interference (this is for comparison to the interference cases).

Control receivers outside the chamber will receive simulator signals just as the receivers inside the chamber do. Real time connection between receivers in the chamber and the control receivers outside the chamber will not be feasible, so post-processing will be required for RTK results. This will permit exploration of modes 2) and 3). Mode 1) can be tested between multiple receivers inside the chamber. Mode 4) will not be tested.

Timing Receivers – Anechoic Chamber Testing

Timing receivers have multiple modes, depending on the particular receiver, which must be tested. The only mode tested under this test plan is Autonomous (stand alone).

High Precision Receivers – Field Testing

To the extent feasible, the LightSquared Live Sky Testing in Las Vegas from 5/15/11 to 5/27/11 will be used for field testing.

Timing Receivers – Field Testing

To the extent feasible, the LightSquared Live Sky Testing in Las Vegas from 5/15/11 to 5/27/11 will be used for field testing.

Anechoic Chamber Testing

Test Structure Requirements

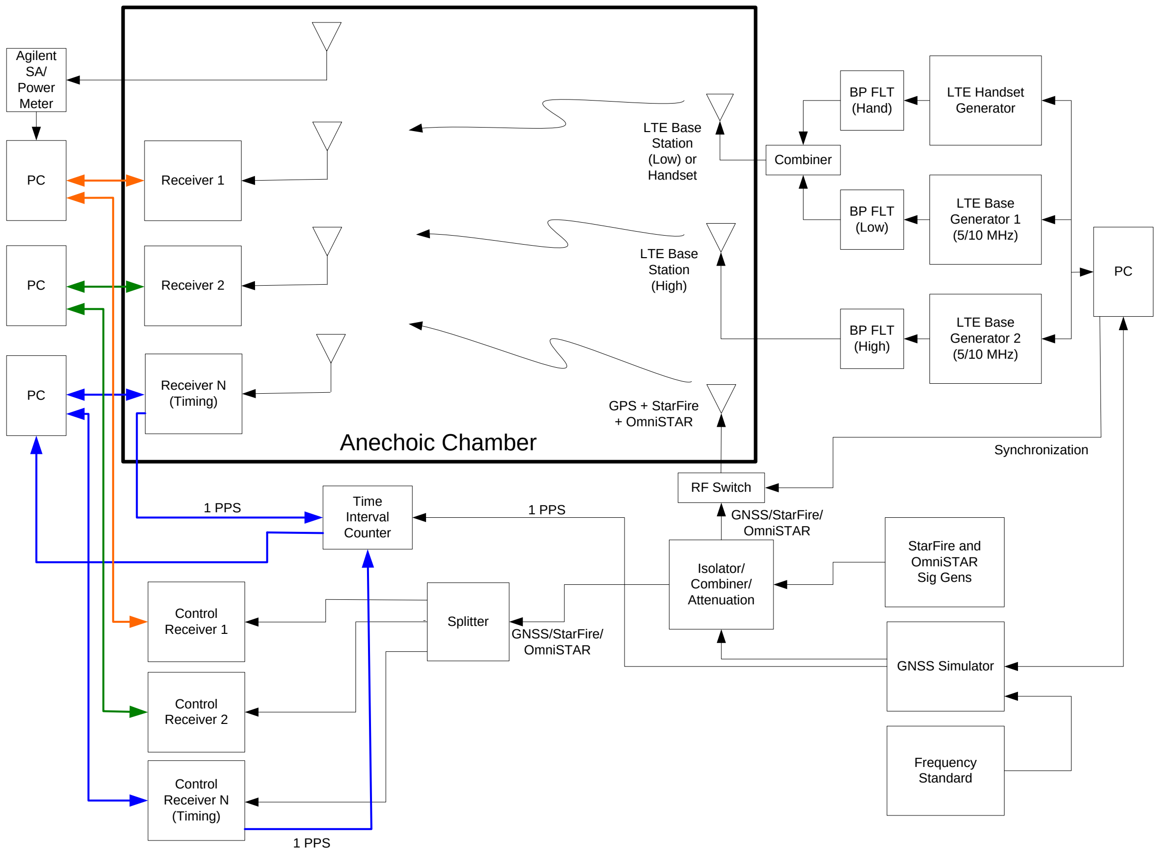
To permit testing that meets the requirements of Section 0, the test structure must have the following characteristics:

1. An anechoic chamber of sufficient size to permit the testing of multiple receivers simultaneously must be available. To avoid geometric effects that could result from having transmitting and receiving antennas too close, at least 5 meters are needed between them.

2. A test structure must be constructed that can hold multiple receivers for the test. All receivers are to be tested simultaneously if possible. Preliminary testing must be done to determine whether there are interactions between receivers as they are placed in the chamber.
3. The signals generated by the LightSquared generators must replicate the signals that will be used in field operations.
4. Calibration of the transmitters and anechoic chamber must be done to ensure the transmitted signals are well characterized and understood. There must be sufficient high quality instrumentation to ensure that the measurements taken are valid.
5. Each high precision manufacturer may have one receiver outside the chamber which will receive the GPS simulator signal to characterize the differences in performance between units subject to LightSquared signals and those not subject to it. This will also enable the RTK test cases to be performed.
6. It must be possible to vary the LightSquared signal power, to generate both the 5 MHz and 10 MHz LightSquared signals, and to operate the two generators simultaneously.
7. It must be possible to generate GPS L1 and L2 satellite signals with varying number of satellites and signal powers. The only GPS signals to be generated are L1 C/A, L1P, and L2P.
8. It must be possible to generate the StarFire and OmniSTAR augmentation signals for those receivers which use them. WAAS will not be used.
9. There must be sufficient isolation and attenuation to ensure that signals from inside the chamber do not feed back or affect the measuring instruments or receivers outside the chamber.
10. The frequency stability of the GNSS Signal Generator must be of higher quality than the oscillators in the Timing UUTs.
11. Each manufacturer should be responsible for setting up a LAN or other data communications structure to enable its receivers to provide data to its logging/control PCs.

Figure 47 below illustrates the test setup.

Figure 47 Test Setup



Physical Test Structure

The anechoic chamber tests will be conducted at the NAVAIR facility in Maryland. The chamber measures 40 ft x 40 ft x 100 ft.

There are two small doors into the chamber, and one large access door. The normal entrance leads into a ground floor lab, and it has a door into the chamber. This door is at the transmit end of the chamber. There is an elevated floor for personnel access to the chamber and which can be used for cabling. The second small door is at the receive end of the chamber and exits outdoors. The large access door is at the receive end of the chamber.

The transmit window is half way up the 40 foot wall (centered 20 ft from the floor and the sides). The opening is about 3 ft x 3 ft. The GPS/StarFire/OmniSTAR antenna will be mounted through the transmit window (there is an upstairs lab behind the transmit window). The LTE transmit antennas will be mounted on a wood structure at the rear of the chamber.

The antennas (and receivers with integral antennas) will be mounted in a grid framework to give them a boresight arrangement with the transmitters. This will require a wood structure that will be partially built outside and assembled inside the chamber. There is a hoist inside the chamber that can be used to erect it inside the chamber. There is a Hi-Reach that can be used to help mount the antennas or receivers after the grid is erected. See Figure 48 and Figure 49.

Figure 48 Antenna/Receiver Grid-1

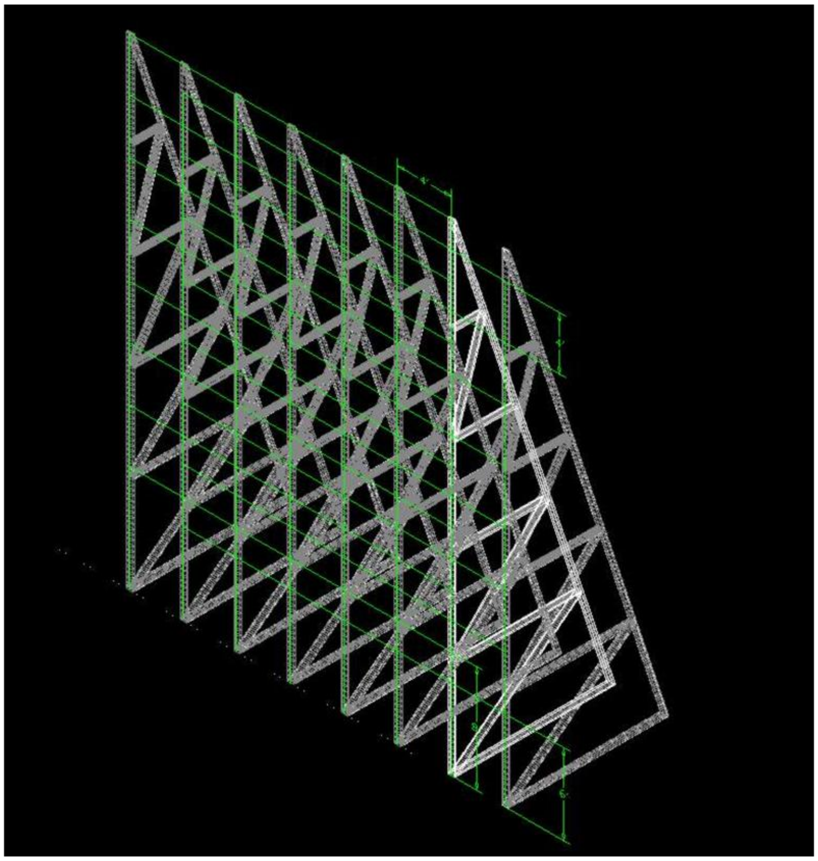
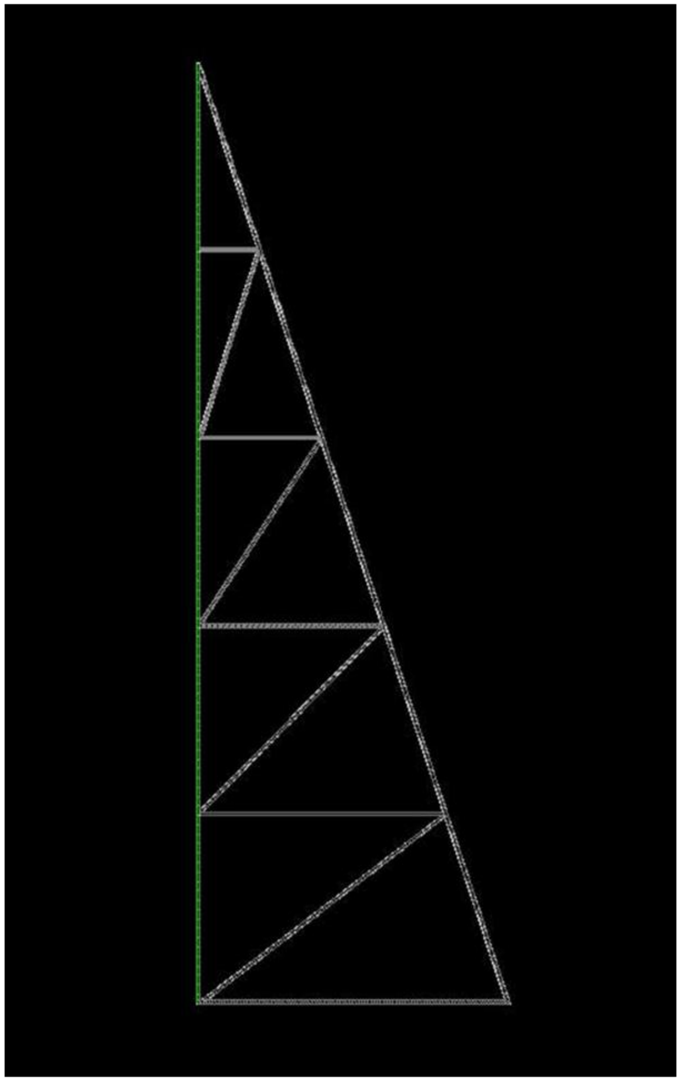


Figure 49 Antenna/Receiver Grid-2



The grid will be constructed so that the receivers can be placed at the bottom of it and sheltered with absorber.

The logging laptops are to be placed in the labs at the transmit end of the chamber.

LightSquared LTE Signals

The LightSquared LTE base station signals will be in the 1525 MHz – 1559 MHz band. The LightSquared handset signals will be in the 1626.5 MHz – 1660.5 MHz band. LightSquared will implement their system in three phases:

- Phase 0: One 5 MHz channel: 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel ($F5_{High}$)
- Phase 1A: Two 5 MHz channels: 1526.3 MHz - 1531.3 MHz ($F5_{Low}$) and 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel

- Phase 2: Two 10 MHz channels: 1526 MHz -1536 MHz ($F10_{Low}$) and 1545.2 MHz - 1555.2 MHz ($F10_{High}$), 62 dBm EIRP per 10 MHz channel

LightSquared plans in all three phases to operate base stations at least 4 MHz away from the GPS band at 1559 MHz.

When both the Low and High LTE base station signals are used, they will be radiated with orthogonal polarizations.

In one test, a simulated handset will be used. The frequency for the handset (HS) will be 1627.5 – 1637.5 MHz. The maximum power from the handset is intended to simulate the effect of having a handset 1 meter from a GPS antenna. The EIRP of the handset is +23 dBm. Allowing for 37 dB path loss, the power at the GPS antenna should be -14 dBm.

The following seven LTE base station and handset carrier frequency configurations will be used for the interference testing:

- $F5_{Low}$
- $F5_{High}$
- $F5_{High}$ + $F5_{Low}$
- $F10_{Low}$
- $F10_{High}$
- $F10_{High}$ + $F10_{Low}$
- HS

These frequencies are chosen to have the potential to create 3rd order intermod products that may fall within the GPS L1 band.

Setup and Calibration of LightSquared LTE Signals

- Since the actual base station antenna cannot be used, a measured, calibrated field strength will be generated using a vertical, linear polarized horn antenna with a known gain. This antenna will be directed with the peak gain pointed at the region where the UUTs will be tested.
- The LTE signal will be pointed directly at the boresight of the UUTs.
- The distance in meters between the face of the horn antenna and the UUTs will be measured and recorded.
- Mount both the LTE horns and the GPS simulator transmit antenna in place with no UUT equipments in place.
- Turn the LTE transmitter on with the attenuator at a known setting and measure the field strength at the locations where the UUTs will be placed.
- Vary the attenuator through at least three settings across the range of LightSquared power and record the field strength to calibrate the attenuator(s), or calibrate the attenuator(s) using a network analyzer.

Note: The equivalent outdoor separation which will have a similar effect can be determined (and bounded) using a propagation model. Some possible choices are:

- Free space model: $(1/R^2)$
- $R_{outdoors}=R_{chamber}*\text{sqrt}(Gain_{LTE\ outdoor\ antenna}/Gain_{Tx\ Horn\ used\ in\ test})$
- Urban environments: $(1/R^{3.5})$
- Walfisch-Ikegami model

The LTE signal will be pointed directly at the boresight of the UUT, while a typical use case will be at a lower elevation. This will likely produce some rolloff and will reduce the equivalent outdoor separation.

Setup and Calibration of GNSS Signals

- The GNSS signal generator shall be locked to a high quality external frequency source.
- The simulator used to generate the GNSS signals will have internal noise that permits the C/N_0 ratios to be set independent of the actual output power. This can be maintained even when using external amplifiers, provided the additional amplifier's noise power is well below the simulator output power.
- The GPS radiating antenna must be right hand circularly polarized and be pointed at the boresight (top or zenith) of the UUTs.
- The antenna gain characteristics of a typical UUT antenna should be entered into the simulator, or an approximation, to correct for elevation variations of the constellation.
- Set the peak C/N_0 to 47 dB-Hz.
- Using a representative UUT and antenna and with the LTE on, record the C/N_0 of the peak satellite and reduce the gain of the GNSS signal until the UUT reports a decrease in C/N_0 of 3 dB. Now the noise in the environment and the simulator are equal and any additional noise will be detected.
- This level and setting must be recorded and used throughout the testing as the reference level.

Setup and Calibration of the Timing Equipment

- Some Timing UUTs will have an associated Time Interval Counter (TIC).
- The primary 1PPS control signal shall be provided by the GNSS Signal Generator.
- If required by the TIC, a stable frequency source can be provided by the GNSS frequency reference.
- Measure and record the steady-state time interval before the LTE signals are applied.

- Use the clean steady-state measurement above as the “truth” value during the subsequent LTE emissions tests.

Interference among Receivers

As receivers are installed in the anechoic chamber, the extent to which any of the receivers suffer interference from the presence of the others must be examined by evaluating each receiver’s performance when it is the only powered receiver and again when all the others are powered.

Data Recording

To the extent possible, the following GPS and augmentation internal performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Pseudorange
- Carrier Phase
- Doppler
- C/N_0
- Optional Parameters (UUT specific)
  - Carrier tracking variance
  - Pseudorange tracking variance
  - Lock Times
  - Lock Breaks
  - Signal Quality
  - L band augmentation communications
    - Packet Error Rate
    - E_b/N_0

To the extent possible, the following GPS and augmentation external performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Position and velocity accuracy (GPS stand alone, augmentation, and RTK)
- Pseudorange accuracy
- Carrier phase accuracy
- Range Rate (Doppler) accuracy
- Mean Time between Cycle Slips
- Mean Time between Lock breaks
- Reacquisition time statistics (Hot Start)
- Acquisition time statistics (Warm and Cold Starts)

- RTK ambiguity resolution statistics
- 1PPS error as measured by the TIC (for timing receivers)
- Receiver Status including Holdover Mode flag (for timing receivers)

Test Automation

Spirent will be providing automation of the LTE generators and the Spirent simulator. There are constraints that apply to this automation:

1. Time from the Spirent GPS simulator will be used to coordinate all testing activities. Time must increase monotonically throughout the tests, but will not be synchronized to real world time.
2. The GPS scenarios in the Spirent simulator will use 24 satellites. The power from the satellites will be set to the minimums specified in ICD-GPS-200C. There will be 4 satellites in each of the 6 GPS planes, with spacing between satellites reasonably uniform.
3. ICD-GPS-200C gives minimum power at 5 degrees elevation of -160 dBW for L1 C/A, -163 dBW for L1P, and -166 dBW for L2P. It shows power increases of up to 2 dB as elevation increases. The curves shown in Figure 6-1 in ICD-GPS-200C should be used for the satellites in this test plan.
4. The receive antenna model used in the Spirent simulator will be that from a standard Dorne and Margolin choke ring, but modified to increase low elevation gain. The gain drop from zenith to horizontal should be 10 dB.
5. The assumed location of the receivers for the Spirent scenarios will be:
    - Latitude: 30° 15'
    - Longitude 76° 25'

Interference Tests

Four types of tests will be conducted:

- Tracking
- Reacquisition
- Tracking Sensitivity
- Acquisition

These are defined in the sections below. The power ranges for the base station tests and the handset test are the same:

- Base station: -85 (MIN) dBm to -15 (MAX) dBm
- Handset: -85 (MIN) dBm to -15 (MAX) dBm

The terms MIN and MAX are used in the test description to refer to these power levels. These power levels assume input into a 0 dBi antenna at the center of the grid.

Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0.

1. Record the performance parameters for each UUT as defined in section 0, including C/N_0.
2. Set each LTE simulator employed for the selected configuration to an output power of MIN dBm (at the receivers).
   a. Record the performance parameters for each UUT and the LTE simulator power for 60 seconds.
   b. Increase the power of the LTE simulators output by 1 dB.
   c. Repeat steps 2a) and 2b) until the output power of the LTE simulators has reached MAX dBm.
3. Dwell at MAX dBm for two minutes.
4. Set each LTE simulator employed for the selected configuration to an output power of MAX dBm.
   a. Record the performance parameters and LTE simulator power for 60 seconds.
   b. Decrease the power of the LTE simulator output by 1 dB.
   c. Repeat steps 4a) and 4b) until the LTE simulator power is set to MIN dBm.
5. From the data collected during 2) - 4):
   a. Each manufacturer will identify two base station configurations as candidates for all subsequent tests.
   b. The Test Coordinator will identify the minimum set of base station configurations that covers all of the candidates provided in 5a). All subsequent tests will be conducted using that reduced set. For time estimating, it will be assumed that four base station configurations will suffice.

Estimated Test Time for Tracking Test Procedure:

1. Seven base station configurations from MIN dBm to MAX dBm at 60 seconds/dB: 7 * 60 * (70 + 10) +7*120 = 34,440 seconds = 9.6 hours.
2. Seven base station configurations from MAX dBm to MIN dBm at 60 seconds/dB: 7 * 60 * (70 + 10) 7*120 = 34,440 seconds = 9.6 hours.
3. Total test time: 9.6 + 9.6 = 19.2 hours.

Reacquisition Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0 5b, the following procedure should be performed with the GPS simulator set up as described in section 0.

1. With LTE power off, collect 15 minutes of tracking performance parameters.
2. For each of the LTE base station configurations:
    a. Set the LTE simulators to a power output of power of MIN dBm (at the receivers).
    b. Record tracking parameters for 30 seconds.
    c. Reduce the GPS signal power to zero for 10 seconds by disconnecting GPS simulator power to the radiating antenna through the use of a RF switch.
    d. Resume GPS signal level to nominal value indicated in section 0.
    e. Repeat 2b) through 2d) for 25 iterations.
    f. Increase LTE power by 5 dB.
    g. Repeat steps 2a) through 2f) until the LTE output power is set to MAX dBm.

Estimated Test Time for Reacquisition Test Procedure

1. Four LTE base station configurations, 17 signal power cases, 25 iterations at 40 seconds/iteration: 900 + 4 * 40 * 5 * 25 = 68,900 seconds = 19.2 hours.

Sensitivity Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the LTE base station configurations specified in section 0 5b), the following procedure should be performed with the GPS simulator set up as described in section 0. The Spirent simulator should be configured for a uniform antenna pattern, i.e., all GPS satellite signals should be set to the same level as specified in section 0.

1. With LTE simulator power off and GPS at nominal signal levels specified in section 0, collect 15 minutes of tracking performance parameters.
2. For each LTE power level from MIN dBm to MAX dBm in 5 dB steps:
    a. Set the power level of the LTE simulators to the specified power.
    b. Continuously record performance data during 2).
    c. Reduce GPS simulator power at a rate of 1 dB/min for 15 minutes.
    d. Set the GPS simulator back to nominal signal level.
    e. Turn the LTE simulator power off.

f. Wait 2 minutes to allow all UUTs to stabilize.

Estimated Test Time for Sensitivity Tracking Test Procedure:

1. Four base station configurations, five LTE power levels, 30 minute iteration for two iterations: 900 + 4 * 17 * 1020 = 70,260 = 19.5 hours.

Acquisition Test Procedure

This test case will be done from a "warm" start condition. The intent is that a normal acquisition processes be conducted between restarts, one that results from having ephemeris and position, but not precise GPS time (bit sync unknown).

For each of the LTE base station configurations specified in section 0 5b), the following procedure should be performed with the GPS simulator set up as described in section 0.

1. Power on all UUTs and record performance data for 5 minutes.
2. For each LTE power level from MIN dBm to MAX dBm in 10 dB steps:
   a. Record performance data for 15 minutes.
   b. During each 15 minute test, each manufacturer should force restarts on their equipment at least every 3 minutes. If proper operation can be established in less time, then restarts can be initiated more often (this is at the manufacturers option). A minimum of 4 restarts should be initiated at each power level.

Estimated Test Time for Acquisition Test Procedure

1. Four base station configurations, nine power levels, 15 minutes per power level: 4* 900 * 9 = 33,000 seconds = 9.2 hours.

Total Test Time

Tracking =	19.2 hours
Reacquisition =	19.2 hours
Tracking Sensitivity =	19.5 hours
Acquisition =	9.2 hours
Total =	67.1 hours

Expected Processing Results

It is expected that each manufacturer will need to use its proprietary software to process the recorded data. The data needs then to be presented in a uniform structure that is amenable to evaluation and aggregation.

Template – High Precision Receivers

The template will be determined following the anechoic chamber testing.

Template – Timing Receivers

The template will be determined following the anechoic chamber testing.

References

ICD-GPS-200C.

Field Testing

To the extent feasible, the LightSquared Live Sky Testing in Las Vegas from 5/15/11 to 5/27/11 will be used for field testing.

Appendix H.1.7

GPS Interference to CORS Stations Las Vegas

During the NOAA / NGS Live sky testing intermittent interference was also detected at several CORS stations close to Site 53. CORS Station locations are shown in Figure 1.

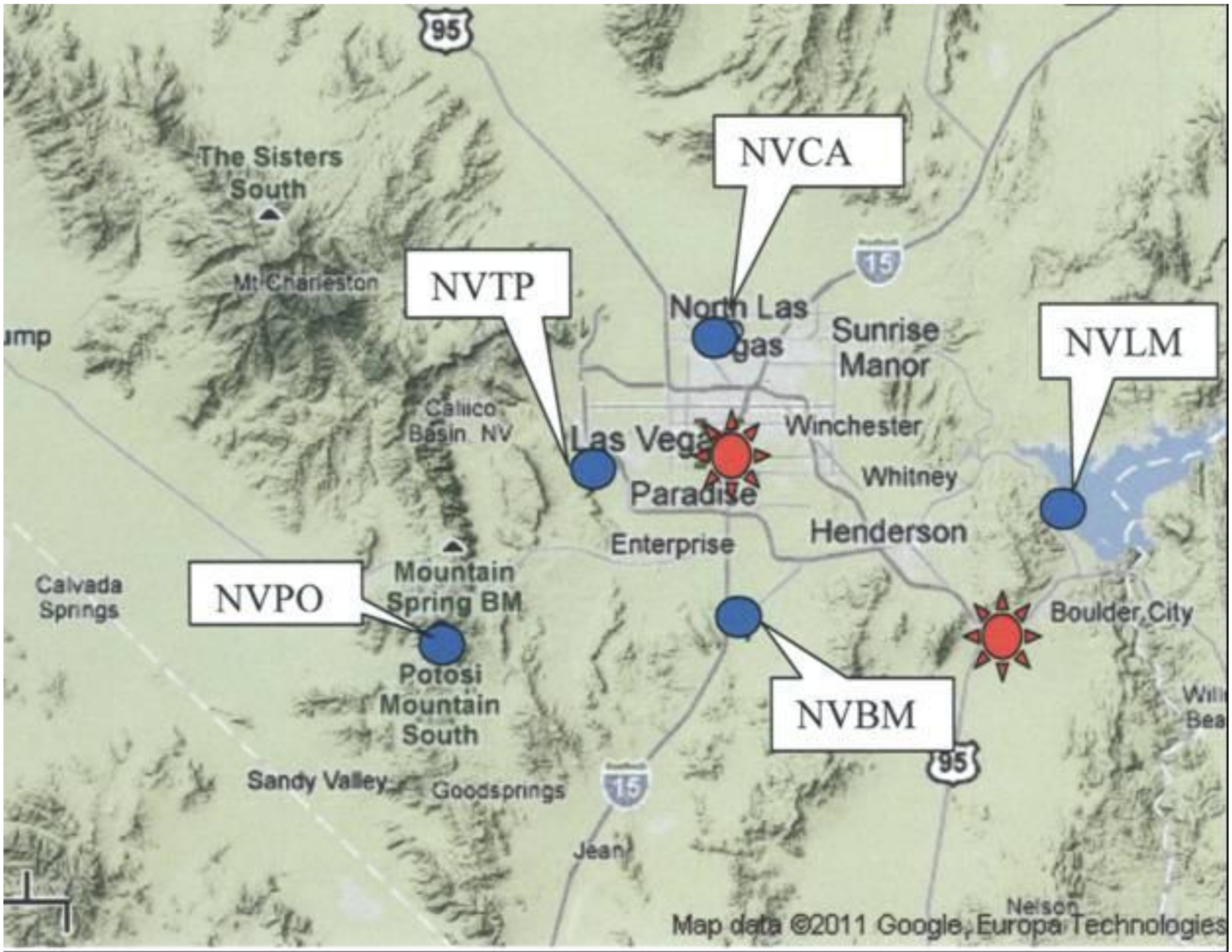


Fig. 1 Approximate location of five CORS stations (blue circles) and the two LightSquared transmitters (red sun) in the Las Vegas, Nevada area. Transmitter LVGS0053-C1 is located within the city of Las Vegas while transmitter LVGS0160-C1 is located to the southeast.

CORS Station	Distance to 0053-C1 (Km)	Distance to 0160-C1 (Km)
NVTP	43.90	12.92
NVBM	26.04	17.71
NVLM	12.18	34.44
NVCA	38.99	10.47
NVPO	56.53	33.46

Table 1. Approximate distances in kilometers from the CORS stations to each LightSquared transmitter.

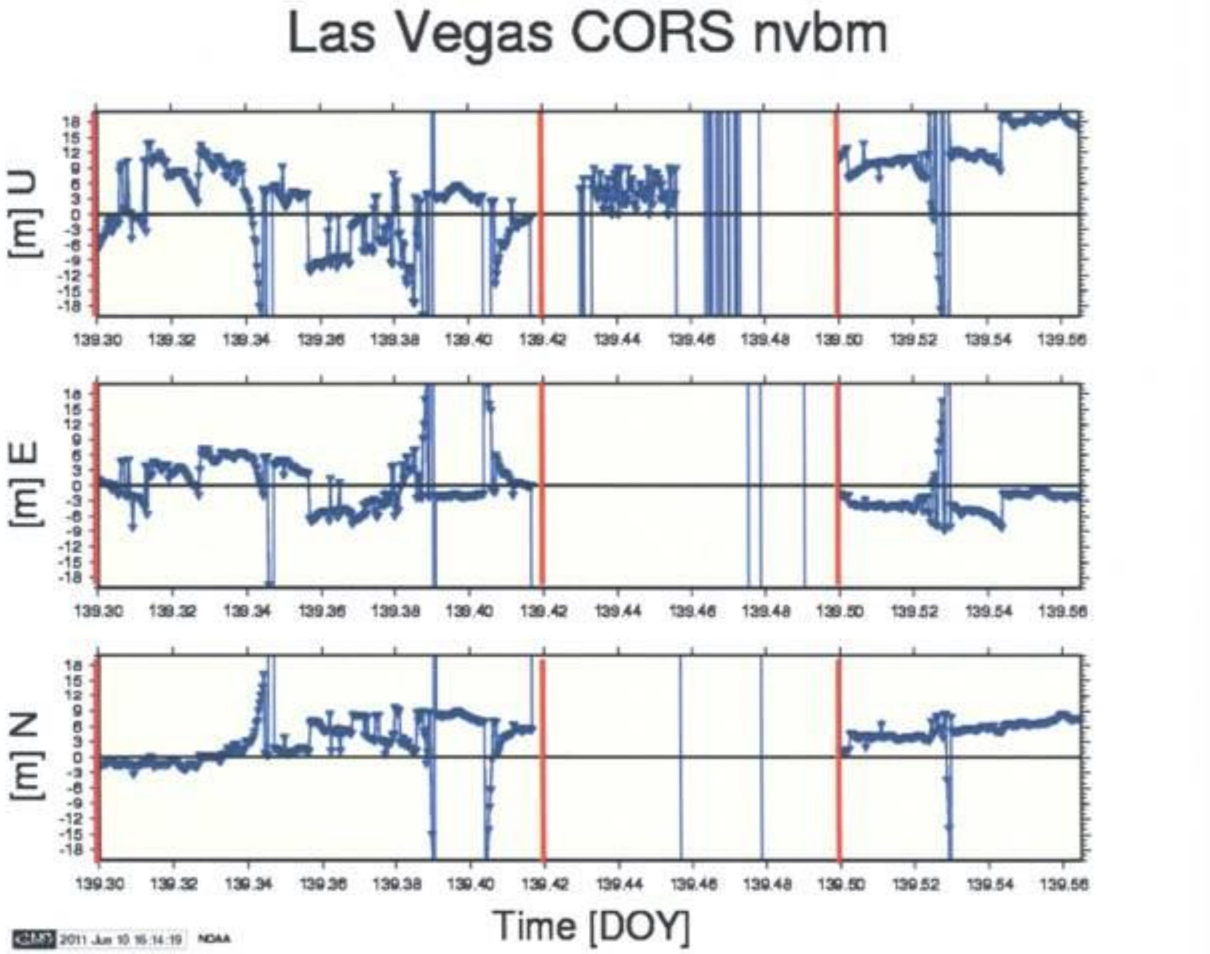


Fig. 2 Coordinate differences at each epoch for CORS station NVBM
on May 19th, 2011, day of year (DOY) 139.

On May 19 CORS station NVBM (26 Km. from Site 53) lost track and was not able to track GPS satellites beginning just before 3:00 am (DOY 139.42) to 5:00 am (DOY 139.50) PDT. CORS Station NVLM (12 Km. from Site 53) was also not able to track GPS satellites during the same time period as shown in Figure 3.

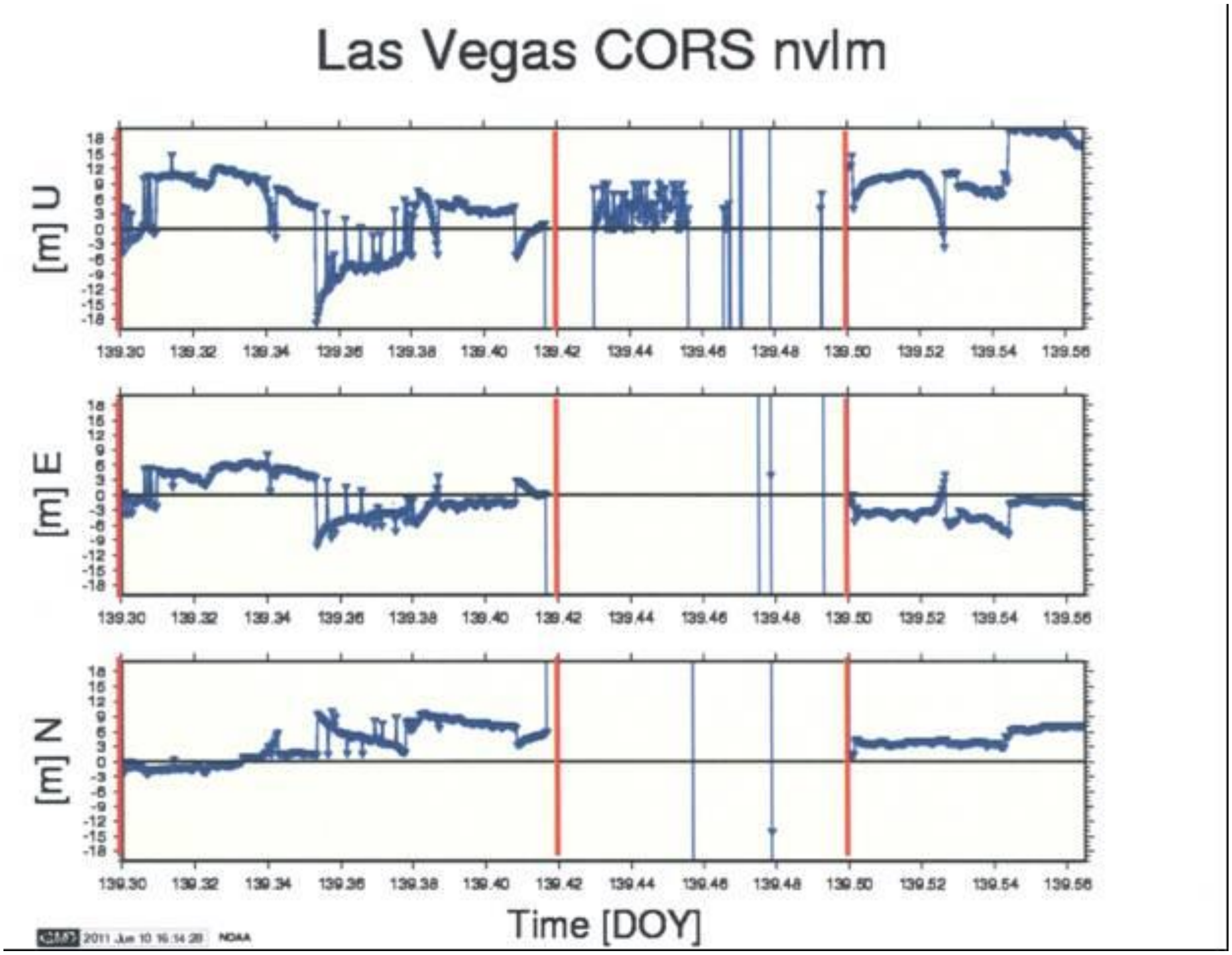


Fig.3 Coordinate differences at each epoch for CORS
station NVLM on May 19th, 2011, day of year (DOY) 139

During two fifteen minute test intervals on May 19 CORS station NVBM exhibited a large step position error in latitude (east error) in excess of 15 m. (12:00 -12:15 AM) and a north and east step error of +6 m. and -6 m. (1:30 -1:45 AM). Under normal tracking conditions, these step function errors are not present. (See Figures 4 &5). CORS station NVLM exhibited tracking errors between from ±9 m. to ±6 m. during most of the test interval (1:30 – 1:45 AM) on May 19 (See Figure 6).

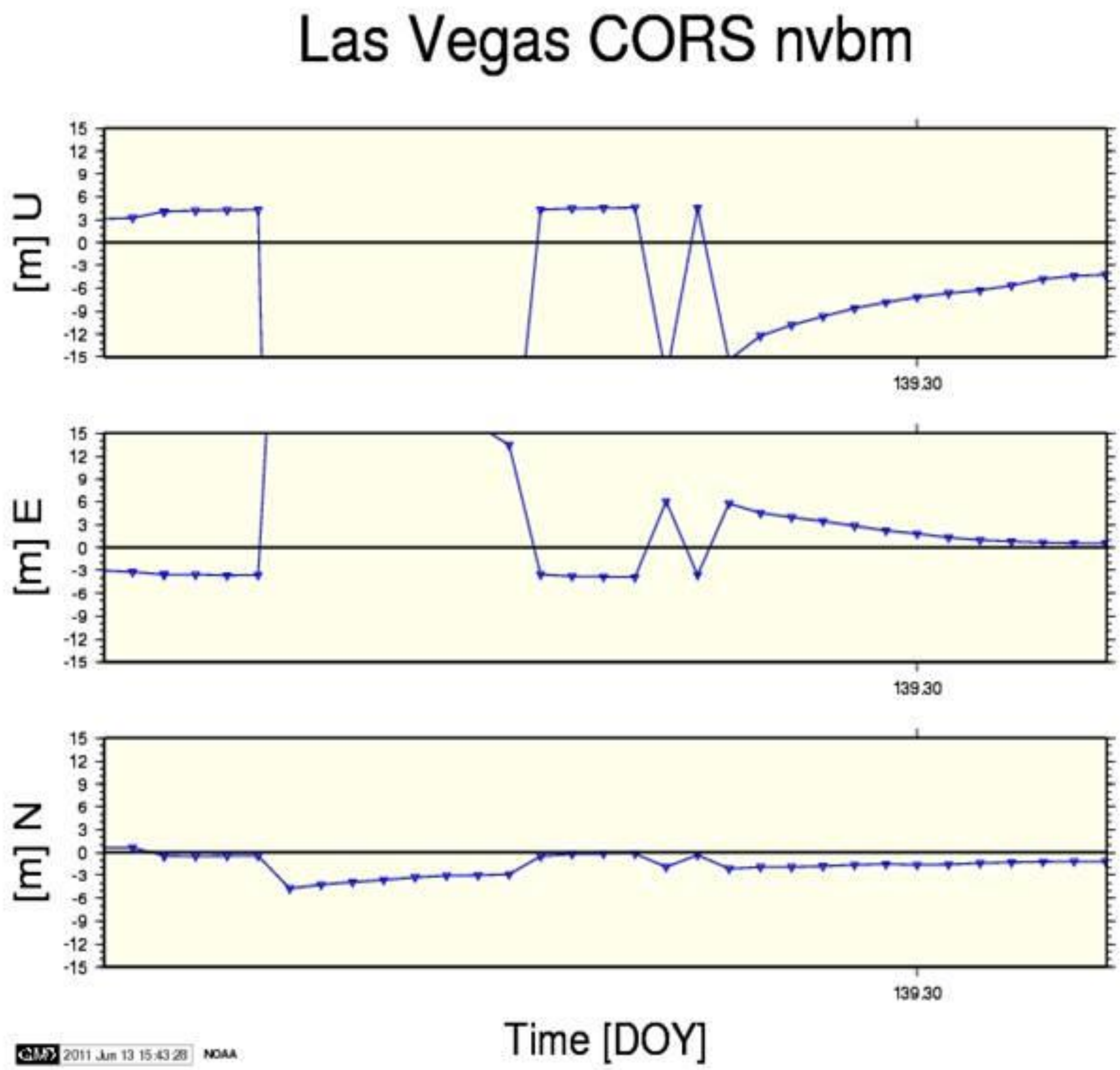


Fig. 4 Large East Error During LightSquared Transmission May 19 (12:00 – 12:15 AM).

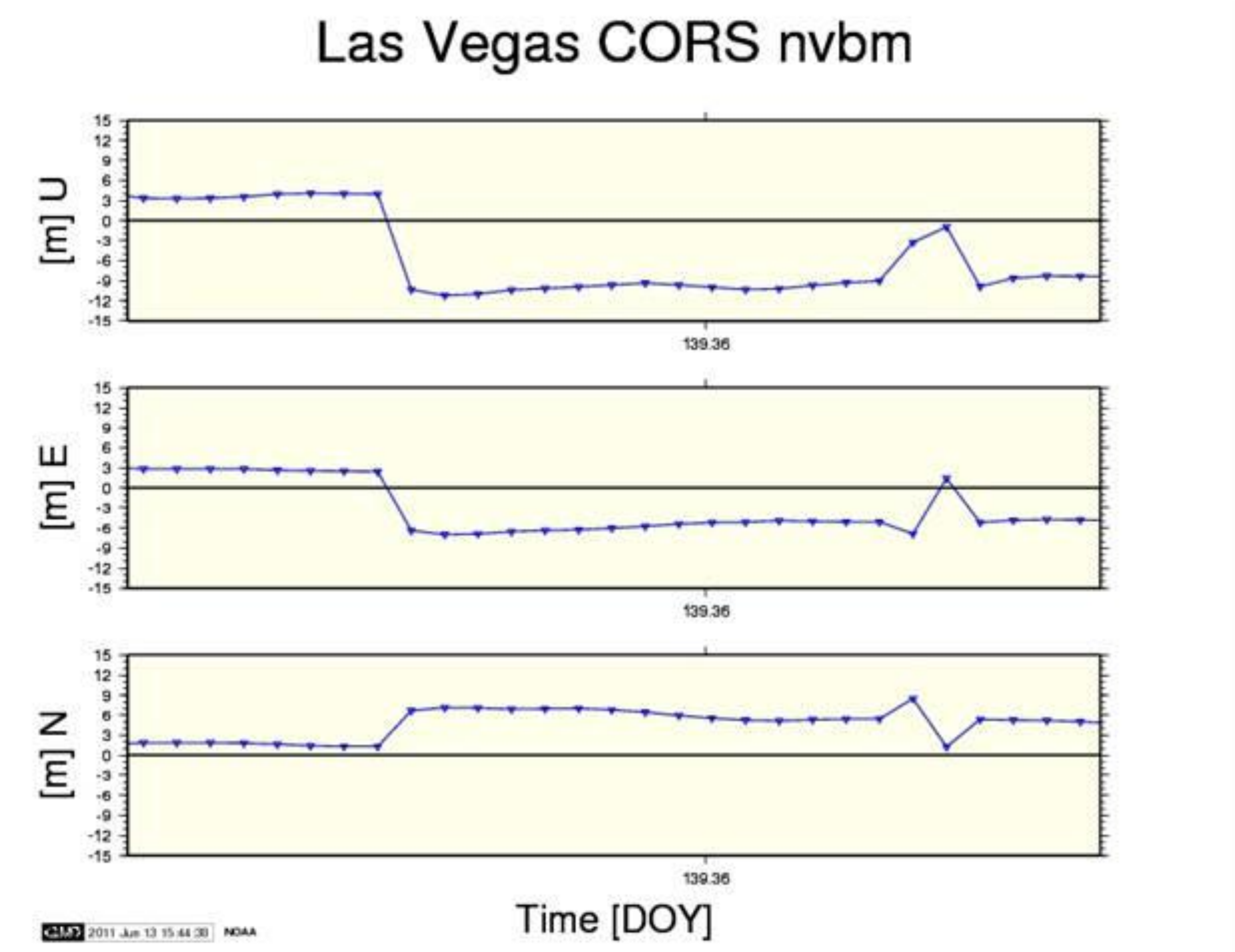


Fig. 5 Step (±6 m.) Errors in North & East During
LightSquared Transmissions on May 19 (1:30 – 1:45 AM)

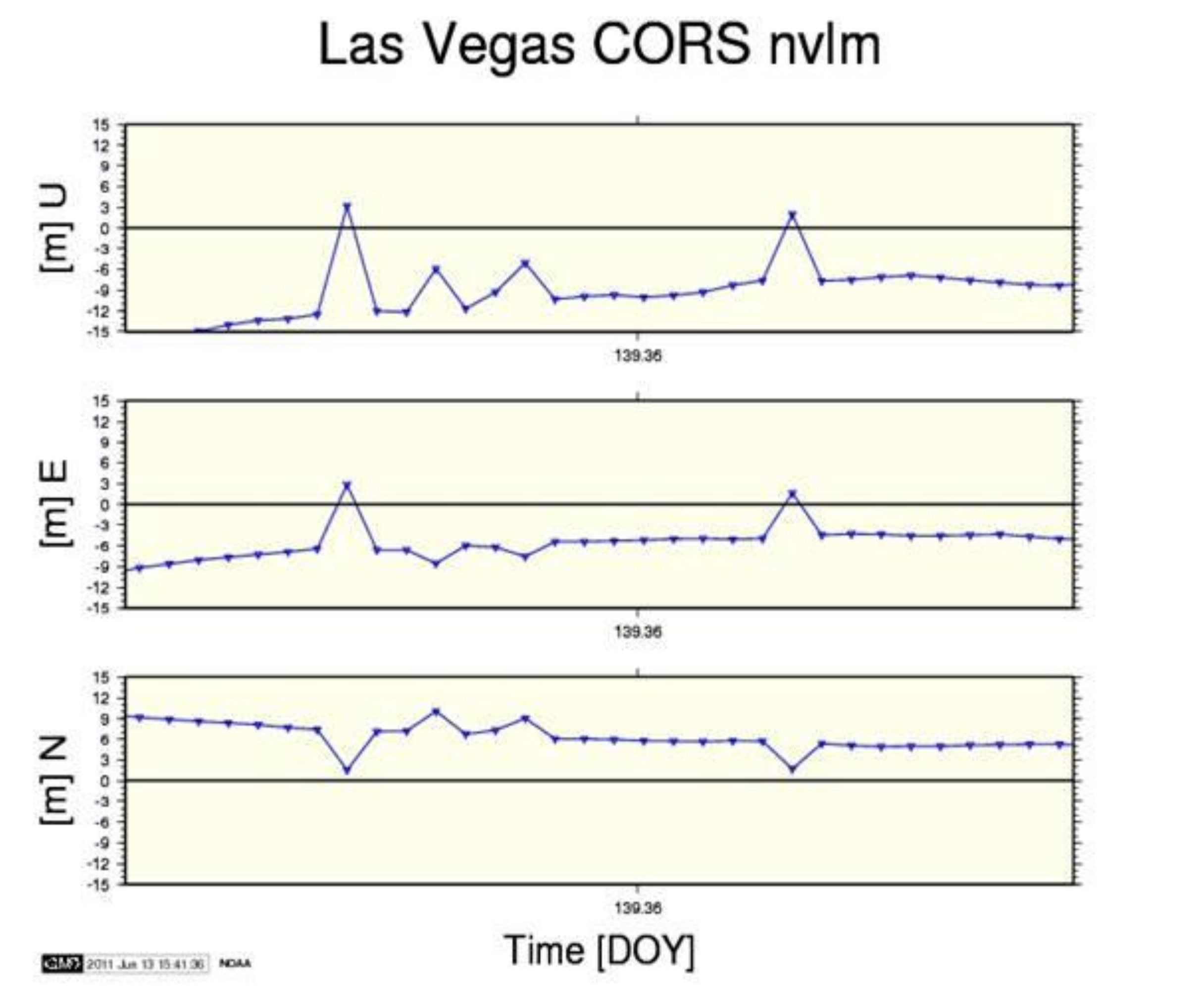


Figure 6 Large North & East Errors (±9 m. to ±6 m.)
During LightSquared Transmissions May 19 (1:30 – 1:45 AM)

Table 2 lists the errors for CORS stations NVBM (26 Km. from Site 53) and NVLM (12 Km. from Site 53) on May 20.

CORS site ID	TIME (Local - PDT)	North / East Errors
NVBM	12:00-12:15 AM	North error in excess of 15 m. during part of test interval
NVBM	2:00 – 2:15 AM	North step error to + 9 m.; East step error ±6 m. during part of test interval
NVBM	2:30 _2:45 AM	North & East errors exceed 15 m. during part of test interval; North error +9m. during most of test
NVLM	1:30 – 1:45 AM	North & East Errors ±9 m. decreasing + 6 m. East error for duration of test.
NVLM	2:30 – 2:45 AM	North error steady at + 9 m. for duration of testing.

Table 2 CORS Station Errors during LightSquared Transmissions May 20

Summary Conclusions

Intermittent interference from the LightSquared signal transmission was noted during NOAA / NGS testing in Las Vegas by several CORS stations 12 and 26 Km. from rural Site 53 on May 19 -20. Specific effects were loss of tracking at CORS stations NVBM and NVLM between 3:00 - 5:00 am on May 19 in addition to North and East errors in excess of +15m. and ±9 m. On May 20 no tracking losses were observed at either station but North and East errors in excess of +15m. and ±9 m. were noted. A possible explanation for the intermittent interference from the LightSquared transmissions is that the Site 53 sectors at 30^0 and 270^0 are pointing directly at CORS sites NVLM and NVBM.

Appendix H.1.8

Sprint Base Station GPS Timing Receiver Testing
Live Sky - Las Vegas

Prepared by: John Latek and Young Zhao

Date: June 14, 2011

Results Summary & Details

Enhanced filtered GPS antennas may be required for all sites within a minimum of 1/4 – 1/3 mile of a LightSquared (LS) transmitting cell site employing the upper 5 MHz carrier (1552.7 MHz). These distances may increase in a dense urban environment where LightSquared would have many transmitters in close proximity.

iDEN and CDMA cell sites that are collocated or in near proximity (minimum of 1/4 to 1/3 mile) of the LightSquared L-band transmitting antennas, while the "upper" frequency was "on", seriously impacted GPS receiver system performance at cell sites having their original GPS antennas in place. The GPS receiver systems at both iDEN and CDMA Sprint cell sites could not track enough satellites, in most cases zero satellites with zero S/N readings, to maintain base station system timing.

The PCTEL model GPS-TMG-HR-26N enhanced filtering antennas mitigate the GPS interference when LightSquared is transmitting both upper and lower 5 MHz carriers even at collocated cell sites.

After installation of the PCTEL enhanced filtered GPS antennas at these sites, there was little to no noticeable GPS receiver interference seen while the LightSquared "upper" and "lower" frequencies were on or off. The PCTEL enhanced filtered antennas mitigate the GPS interference even at collocated Sprint sites with LightSquared transmitting both "upper" and "lower" frequencies simultaneously.

LightSquared transmitting only the lower 5 MHz carrier (1528.8 MHz) does not noticeably impact Sprint cell site GPS receiver performance even at collocated sites.

There was little to no noticeable GPS interference seen at these cell sites seen while LightSquared transmitted only the "lower" frequency even at the Sprint sites equipped with their original GPS antennas. LightSquared transmitting only the "lower" carrier showed little to no degradation to Sprint cell site GPS receiver system performance.

Several factors are involved in how Sprint cell site GPS receiver systems are impacted by the presence of the LightSquared "upper" carrier at the specified power level of 32dBW/carrier (29 dBW/carrier/MIMO branch). These include the distance between the LightSquared transmitting antenna in relation to the cell site GPS antennas, the location of the GPS antennas in relation to the LightSquared transmit antenna main lobe and if and how the cell site GPS antennas are shadowed from the LightSquared transmitting antenna.

Field Test & Equipment Description

The testing objective was to characterize the performance of Sprint cell site GPS receivers (the devices under test, or DUT's) in the presence of L-band base station downlink signals in an outdoor environment with live GPS satellite signals. Production base station transmitter subsystems (including production PA's, filters and other RF components) and antennas were used by LightSquared. Antennas were mounted at heights that were representative of actual deployment including 2^0 electrical antenna down tilts. The antennas comprised 45^0 cross-polarized elements fed by separate PA's emitting MIMO signals. The base station installations were representative of actual deployment as well. As per the initial deployment plan, the base stations emitted L-band signals at the full 32dBW/carrier (29 dBW/carrier/MIMO branch). 100% loading was emulated using dummy user data.

The tests were performed in morphologies that can be roughly classified as Dense Urban, Urban, Suburban, and Rural. Four cell sites, one in each morphology, were selected in Las Vegas by LightSquared. LightSquared used two carrier frequencies at bandwidths of 5 MHz each designated as the "upper" and "lower" frequencies. Each of the four L-band LTE cell sites employed these two 5 MHz carriers, each at 32 dBW, in each of 3 sectors. The two LTE 5 MHz carrier downlink center frequencies were 1552.7 MHz (upper) and 1528.8 MHz (lower). Some limited tests were also performed with the two carriers individually.

The Sprint cell site tests were conducted from May 22th through the 26th during the night and early morning hours. On each night, testing began at 12:00 AM in the maintenance window, and ended at 5:45 AM each morning. To determine the differential impact of the L-band signals on GPS receivers, an on-off method of applying the L-band signals, with a sufficiently short time separation between on and off modes, was used. The L-band signals were applied for a known period of time of 15 minutes at full power; then they were turned off for the same 15 minute period of time. This cycle was repeated for each individual measurement phase.

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Field Test Methodology

Several iDEN and CDMA cell sites were chosen. GPS receiver performance was monitored at these sites during the testing phases. The cell sites chosen for evaluation are identified as;

iDEN Sites

NV6366 R – collocated with LS test site LVGS0068 (suburban)

NV7372R – collocated with LS test site LVGS0053 (rural)

NV6361R - in close proximity to LS site LVGS0217 (dense urban)

NV5301R – approximately ¾ mile from LS site LVGS0217 (dense urban)

CDMA Sites

VG03XC024 - collocated with LS test site LVGS0068 (suburban)

VG60XC304 - collocated with LS test site LVGS0160 (urban)

VG50XC176 - in close proximity to LS site LVGS0217 (dense urban)

VG98XC050 – in close proximity to LS site LVGS0217 (dense urban)

The following KPI data was collected at each Sprint cell site both with and without the L-band signals present and with the current GPS site antennas in place and then with the PCTEL enhanced filtered GPS antennas in place.

1. Number of tracked satellites
2. ID of tracked satellites
3. S/N level for the tracked satellites

Results Summary For iDEN Cell Sites

NV6366R – collocated with LightSquared test site LVGS0068 (suburban)

LS transmitting upper frequency – (original GPS antennas) lost tracking on all satellites.

LS transmitting lower frequency – (original GPS antennas) all satellites tracked no noticeable degradation in S/N.

LS transmitting upper and lower (with PCTEL antennas) – all satellites tracked no noticeable degradation in S/N.

NV7372R – collocated with LightSquared test site LVGS0053 (rural)

LS transmitting upper and lower frequency – (original GPS antennas) lost tracking on all satellites.

LS transmitting upper and lower (with PCTEL antennas) – all satellites tracked no degradation in S/N.

NV6361R – in near proximity to LightSquared test site LVGS0217 (dense urban)

LS transmitting upper and lower frequency (primary GPS feed with original GPS antennas) – able to track all satellites however

observed a degradation of S/N of approximately 8-10 dB.

NV6361R – in near proximity to LightSquared test site LVGS0217 (dense urban)

LS transmitting upper and lower frequency (secondary GPS feed with original GPS antennas) – lost tracking on all satellites.

NV5301R – in near proximity to LightSquared test site LVGS0217 (dense urban)

LS transmitting upper and lower frequency – (original GPS antennas) all satellites tracked no degradation in S/N.

iDEN cell site was shadowed by tall buildings near LS transmit site.

Results Summary For CDMA Cell Sites

VG03XC024 – collocated with LS test site LVGS0068 (suburban)

LS transmitting upper frequency – lost tracking on some satellites. Cell site GPS antenna was shadowed by a microwave dish and antenna standoff arm on the tower. GPS remained locked however.

LS transmitting lower frequency – all satellites tracked no noticeable degradation in S/N.

LS transmitting upper and lower (with PCTEL antennas) – all satellites tracked no degradation in S/N.

VG60XC304 - collocated with LS test site LVGS0160 (urban)

LS transmitting upper and lower frequency – was able to track all satellites. GPS remained locked. The base station and GPS antenna were located approximately 8 - 10 feet from the base of the monopole tower. The GPS receiver may have resided in a null region of the LS transmit antenna. Another possibility is that LS was not transmitting full power at the time the GPS measurements were made.

LS transmitting lower frequency – all satellites tracked no degradation in S/N.

VG50XC176 - in close proximity to LS site LVGS0217 (dense urban)

LS transmitting upper and lower frequencies – lost all satellite tracking when LS was transmitting.

LS transmitting lower frequency only – no noticeable degradation. All satellites remained tracked.

VG98XC050 – in close proximity to LS site LVGS0217 (dense urban)

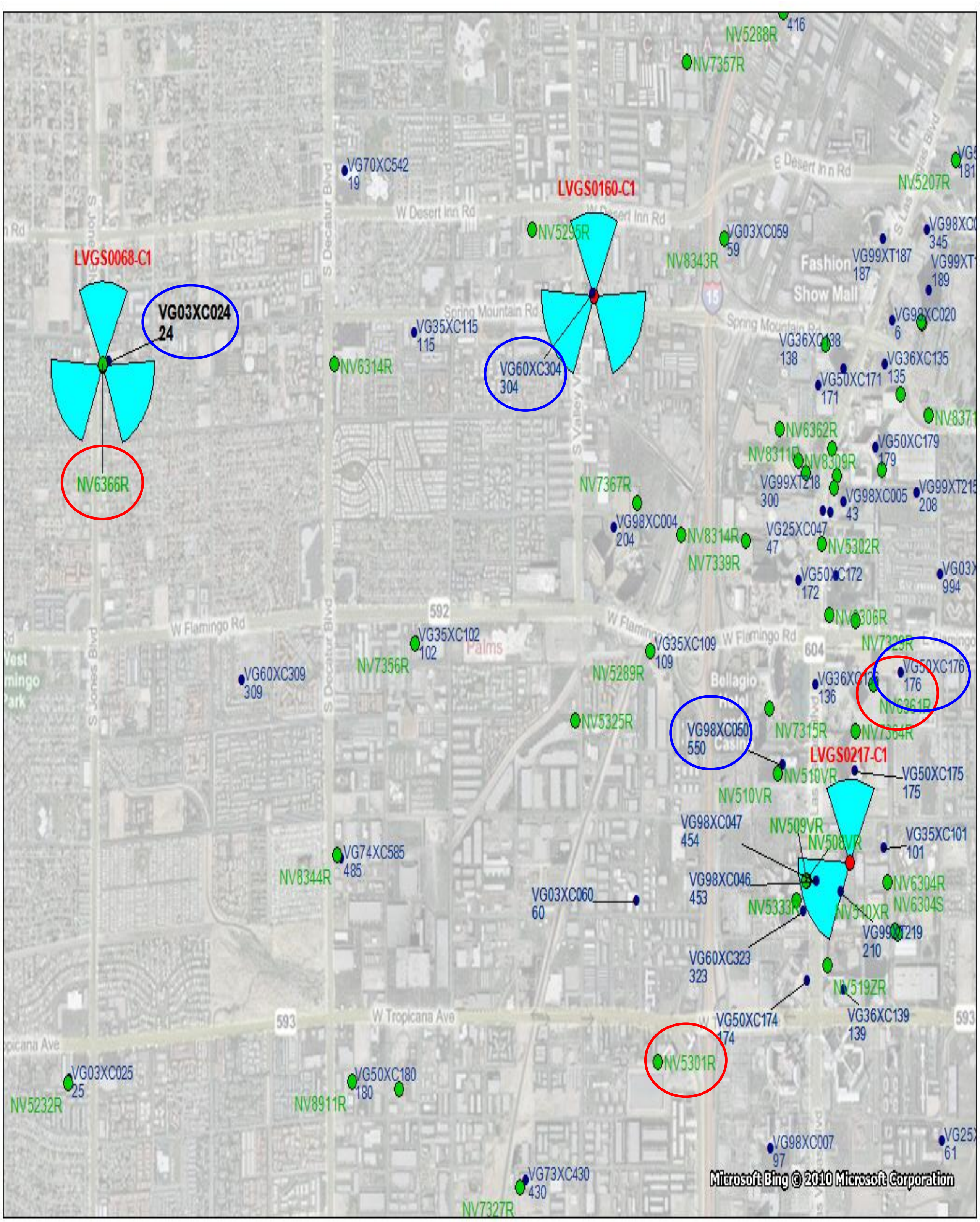
We were not able to access this site due to security concerns. Alarm viewer showed this site experienced GPS alarms when LS transmitted upper and lower frequencies on 5/26*.*

Test Plan Schedule & Details

		Frequency Bands to be tested		Sites to be tested			
Test Day	Date	1526.3- 1531.3 LOWER BAND	1550.2 -1555.2 UPPER BAND	Site #68	Site #160	Site #217	Site #53
1	5/16/2011		X	X		X	
2	5/17/2011	X	X	X		X	
3	5/18/2011	X		X		X	
4	5/19/2011		X		X		X
5	5/20/2011	X	X		X		X
6	5/21/2011	X		X		X	
7	5/22/2011		X	X	X	X	
8	5/23/2011	X		X	X	X	
9	5/24/2011	X	X		X		X
10	5/25/2011	X			X		X
11	5/26/2011	X	X	X	X	X	
12	5/27/2011	X	X				X

Table 1. Test Schedule and Details

Site Maps (iDEN & CDMA)



Site Maps iDEN

Additional Observations

Two iDEN sites experienced service affecting events during the LS testing period, sites NV6366R and NV7372R, both collocated with LS transmitters. Using the alarm view tool, we were able to see that base radios were locked and then unlocked and re-keyed approximately 3 minutes and 20 seconds later. This event occurred twice at site NV6366R and once at site NV7372R. It appears to be related with the LS transmitter testing, however these events occur during LS transmitter “off” times during the testing period and are shown in RED on the following slide. Also, looking back in time several months before the LS testing began there are no records of these type of events occurring at either of these iDEN cell sites.

The events appear to occur only when a standby GPS becomes disabled, then experiences a critical fault . An example of the alarm log is included on the following page. This particular example occurs after the first LS transmit cycle was completed on 5/22 at site NV6366R at 12:19 AM. This about 4 minutes after LS had de-keyed after their first transmit cycle period (12:00 – 12:15 AM). We returned to site NV6366 and verified that the site operates normally on both the Primary and Secondary AGC’s (iSC’s). Regardless, if the LS transmitter was on permanently, the site would have went out of service eventually due to the GPS receiver not having the ability to track any satellites.

There were several LS transmit “on” periods where the TX power out appeared to be low or the site was not configured properly. At LS site 53 on 5/24, for the first three transmit cycles, the base station cabling was not configured correctly. we witnessed this and were able to confirm the problem through the data we were collecting. The issue was resolved and about halfway through the 4th transmit cycle, we lost all tracked satellites, as expected. Then again during the 6th transmit cycle, we were still able to track 3 satellites up to 3 minutes into the cycle then lost all tracked satellites through the remainder of the TX cycle.

On 5/22 at site NV6366R we noticed a similar issue on several of the LS transmit on cycles. On the 4th and 5th LS transmit cycles we were still able to track all satellites and had normal S/N readings. On the 7th transmit cycle we were able to track 2 satellites with degraded S/N readings. The low transmit power problem was also seen by the drive test teams in the area. When we mentioned what we were seeing at the iSC GPS receiver, the LS person at the site commented that the drive testers thought they were also experiencing low transmit power levels from LS.

LS did supply and replace the original GPS antennas with PCTEL enhanced filtered units at the following Sprint cell sites;
NV6366R
NV7372R
VG03XC024

Alarm Log Example of Service Affecting Event

Sprint
Together with NEXTEL

BR	NNV6366R_ISprgMeadw, BR 23, BRC 1	[5] BR LOCKED BY ACG		5/22/2011 0:19
EBTS	NNV6366R_ISprgMeadw, EBTS 1, active ACG	[702] ACTIVE ACG DISABLED		5/22/2011 0:19
EBTS	NNV6366R_ISprgMeadw, EBTS 1, active ACG	[708] ACTIVE ACG CRITICAL FAULT		5/22/2011 0:19
CELL	NNV6366R_ISprgMeadw, CELL 1, active ACG	[104] CELL BEING LOCKED BY ACG		5/22/2011 0:19
CELL	NNV6366R_ISprgMeadw, CELL 2, active ACG	[104] CELL BEING LOCKED BY ACG		5/22/2011 0:19
CELL	NNV6366R_ISprgMeadw, CELL 3, active ACG	[104] CELL BEING LOCKED BY ACG		5/22/2011 0:19
BR	NNV6366R_ISprgMeadw, BR 31, BRC 1	[5] BR LOCKED BY ACG		5/22/2011 0:19
CELL	NNV6366R_ISprgMeadw, CELL 3, active ACG	[106] CELL LOCK SUCCESSFUL		5/22/2011 0:19
BR	NNV6366R_ISprgMeadw, BR 22, BRC 1	[5] BR LOCKED BY ACG		5/22/2011 0:19
BR	NNV6366R_ISprgMeadw, BR 11, BRC 1	[5] BR LOCKED BY ACG		5/22/2011 0:19
STANDBY_SRI/TFR	NNV6366R_ISprgMeadw, STANDBY_SRI/TFR 1, standby ACG	[951] STANDBY GPS CRITICAL FAULT		5/22/2011 0:19
STANDBY_ACG	NNV6366R_ISprgMeadw, STANDBY_ACG 1, standby ACG	[801] STANDBY GPS DISABLED		5/22/2011 0:19
STANDBY_SRI/TFR	NNV6366R_ISprgMeadw, STANDBY_SRI/TFR 1, standby ACG	[955] STANDBY GPS SENT TO IDLE		5/22/2011 0:19
EBTS	NNV6366R_ISprgMeadw, EBTS 1, active ACG	[704] STANDBY ACG LOCKED		5/22/2011 0:19
EBTS	NNV6366R_ISprgMeadw, EBTS 1, active ACG	[703] ACTIVE ACG ACTIVE		5/22/2011 0:15
STANDBY_SRI/TFR	NNV6366R_ISprgMeadw, STANDBY_SRI/TFR 1, standby ACG	[953] STANDBY GPS FREERUN ENDED		5/22/2011 0:15
STANDBY_ACG	NNV6366R_ISprgMeadw, STANDBY_ACG 1, standby ACG	[802] STANDBY GPS ACTIVE		5/22/2011 0:15
STANDBY_SRI/TFR	NNV6366R_ISprgMeadw, STANDBY_SRI/TFR 1, standby ACG	[952] STANDBY GPS FREERUN STARTED		5/22/2011 0:00
STANDBY_ACG	NNV6366R_ISprgMeadw, STANDBY_ACG 1, standby ACG	[800] STANDBY GPS IMPAIRED		5/22/2011 0:00

iDEN Site NV6366R/LS Site 68, LS Upper Frequency Only, w/Original GPS Antennas

iDEN site NV6366R (with original GPS antennas) collocated with L2 site 68

GPS receiver status with no L2 “upper” frequency transmission

```
iSC> status gps
6 satellites tracked
6 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     25     8      52
      5     8      49
     29     8      52
     12     8      50
      2     8      53
     10     0       0
     21     8      47
      0     0       0
      0     0       0
      0     0       0
      0     0       0
      0     0       0
Latitude      N  36 deg  7 min 28.415 sec
Longitude     W 115 deg 13 min 27.782 sec
Altitude        691.1 meters above sea level
Date/Time     05/22/2011   08:28:56 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.624 sec
Hold Longitude     W 115 deg 13 min 27.784 sec
Altitude        703.5 meters above sea level
```

GPS receiver status with L2 “upper” frequency transmission “ON”

```
iSC> status gps
0 satellites tracked
0 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     25     0       0
      5     0       0
     29     0       0
     12     0       0
      2     0       0
     10     0       0
     21     0       0
      0     0       0
      0     0       0
      0     0       0
      0     0       0
      0     0       0
Latitude      N  36 deg  7 min 28.624 sec
Longitude     W 115 deg 13 min 27.784 sec
Altitude        703.5 meters above sea level
Date/Time     05/22/2011   08:31:31 GMT
Position hold status is TRUE
Hold Latitude      N  36 deg  7 min 28.624 sec
Hold Longitude     W 115 deg 13 min 27.784 sec
Altitude        703.5 meters above sea level
```

iDEN site NV6366R (with original GPS antennas) collocated with L2 site 68

GPS receiver status with no L2 “lower” frequency transmission

```
iSC> status gps
8 satellites tracked
8 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     51
     25      8     52
      5      8     50
     21      8     39
     12      8     40
      2      8     42
     26      8     41
     15      8     44
      0      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  7 min 28.337 sec
Longitude     W 115 deg 13 min 27.754 sec
Altitude        679.8 meters above sea level
Date/Time     05/23/2011   08:59:16 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.285 sec
Hold Longitude     W 115 deg 13 min 27.784 sec
Altitude        694.8 meters above sea level
```

GPS receiver status with L2 “lower” frequency transmission “ON”

```
iSC> status gps
8 satellites tracked
8 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     50
     25      8     52
      5      8     51
     21      8     37
     12      8     49
      2      8     41
     26      8     46
     15      8     45
      0      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  7 min 28.228 sec
Longitude     W 115 deg 13 min 27.706 sec
Altitude        687.2 meters above sea level
Date/Time     05/23/2011   09:02:35 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.285 sec
Hold Longitude     W 115 deg 13 min 27.784 sec
Altitude        694.8 meters above sea level
```

iDEN site NV6366R (with enhanced GPS antennas) collocated with L2 site 68

GPS receiver status with no L2 "upper and lower" frequency transmission

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     14      8     46
      9      8     46
     27      8     44
      6      8     51
      3      8     45
     19      0      0
     21      8     51
     22      8     45
      0      0      0
      0      0      0
     18      8     49
     15      8     38
Latitude      N  36 deg  7 min 28.249 sec
Longitude     W 115 deg 13 min 27.751 sec
Altitude        684.3 meters above sea level
Date/Time     05/26/2011   12:28:38 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.507 sec
Hold Longitude     W 115 deg 13 min 27.747 sec
Altitude        687.9 meters above sea level
```

GPS receiver status with L2 "upper and lower" frequency transmission "ON"

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     14      8     45
      9      8     46
     27      8     46
      6      8     54
      3      8     46
     19      0      0
     21      8     45
     22      8     44
      0      0      0
      0      0      0
     18      8     46
     15      8     40
Latitude      N  36 deg  7 min 28.262 sec
Longitude     W 115 deg 13 min 27.729 sec
Altitude        682.6 meters above sea level
Date/Time     05/26/2011   12:33:13 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.507 sec
Hold Longitude     W 115 deg 13 min 27.747 sec
Altitude        687.9 meters above sea level
```

CDMA Site VG03XC024 /LS Site 68, LS Upper Frequency, w/Original GPS Antenna

Time (LS upper band)	Visible Satellites/Tracked Satellites (CTU 1)	Visible Satellites/Tracked Satellites (CTU 2)
12:00	8/7	8/7
12:10	8/2	8/2
2:00	7/6	9/5
2:09	9/6	9/5
2:12	9/5	9/6
2:15	9/9	9/4
2:30	8/7	8/7
2:32	8/6	8/4
2:33	8/6	8/4
2:37	8/7	8/4
2:41	7/6	7/4
2:43	7/7	7/4
2:44	7/7	7/4
2:46	7/7	7/4
2:47	7/7	7/6
2:57	7/7	7/7
2:58	7/7	7/7
3:01	8/7	8/7
3:02	8/7	8/6
3:03	8/7	8/5
3:05	8/7	8/7
3:11	8/7	8/5
3:14	8/7	8/5
3:16	8/7	8/6
3:17	8/7	8/7
5:18	8/8	8/8

During LS transmitter ON times with upper frequency only, there was some degradation seen on GPS receiver performance as tracking was lost on some satellites. The GPS antenna on this CDMA base station was shadowed by a microwave dish and antenna standoff bracket on the tower from the LS transmitting antenna. There was not a total loss of GPS satellite tracking.

CDMA Site VG03XC024 /LS Site 68, LS Lower Frequency, w/Original GPS Antenna, then PCTEL GPS Antenna

Time (LS lower band)	Visible Satellites/Tracked Satellites (CTU 1)	Visible Satellites/Tracked Satellites (CTU 2)
11:45	9/9	9/9
11:55	8/8	8/8
11:58	8/8	8/7
12:01	8/7	8/7
12:09	8/8	8/8
12:12	7/7	7/7
12:14	7/6	7/6
12:18	7/6	7/6
12:25	7/6	7/6
12:28	7/7	7/7
12:31	7/7	7/7
12:35	6/5	6/6
12:40	6/5	6/6
1:16	9/9	9/9
PCTEL GPS antenna		
1:31	8/8	8/8
1:35	8/8	8/8
1:40	7/7	7/7
1:42	7/7	7/7
1:44	7/7	7/7
1:52	7/6	7/7
2:09	8/6	8/6
2:16	8/8	8/7
2:20	8/7	8/8
2:32	9/8	9/9
2:35	9/8	9/7
2:40	7/7	7/7
2:44	8/7	8/7

No impact to GPS receiver performance seen with LS transmitting only lower carrier. With PCTEL antenna installed, again no impact seen to GPS performance.

iDEN site NV7372R (with original GPS antennas) collocated with L2 site 53
Original iDEN GPS antennas – LARSEN Radiall Model GPS0015

GPS receiver status with no L2 "upper and lower" frequency transmission

```
iSC> status gps
8 satellites tracked
8 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     53
     25      8     48
      5      8     47
     12      8     51
     21      8     48
      2      8     38
     26      8     41
     15      8     46
      0      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  35 deg 58 min 10.957 sec
Longitude     W 114 deg 52 min  5.289 sec
Altitude        735.4 meters above sea level
Date/Time     05/24/2011   08:58:47 GMT
Position hold status is FALSE
Hold Latitude      N  35 deg 58 min 10.953 sec
Hold Longitude     W 114 deg 52 min  5.267 sec
Altitude        735.8 meters above sea level
```

GPS receiver status with L2 "upper and lower" frequency transmission "ON"

```
iSC> status gps

0 satellites tracked
0 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      0      0
     25      0      0
      5      0      0
     12      0      0
     21      0      0
      2      0      0
     26      0      0
     15      0      0
     18      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  35 deg 58 min 10.953 sec
Longitude     W 114 deg 52 min  5.267 sec
Altitude        735.8 meters above sea level
Date/Time     05/24/2011   09:00:46 GMT
Position hold status is TRUE
Hold Latitude      N  35 deg 58 min 10.953 sec
Hold Longitude     W 114 deg 52 min  5.267 sec
Altitude        735.8 meters above sea level
```

iDEN site NV6366R (with enhanced GPS antennas) collocated with L2 site 68

GPS receiver status with no L2 “upper and lower” frequency transmission

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     14      8     46
      9      8     46
     27      8     44
      6      8     51
      3      8     45
     19      0      0
     21      8     51
     22      8     45
      0      0      0
      0      0      0
     18      8     49
     15      8     38
Latitude      N  36 deg  7 min 28.249 sec
Longitude     W 115 deg 13 min 27.751 sec
Altitude        684.3 meters above sea level
Date/Time     05/26/2011   12:28:38 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.507 sec
Hold Longitude     W 115 deg 13 min 27.747 sec
Altitude        687.9 meters above sea level
```

GPS receiver status with L2 “upper and lower” frequency transmission “ON”

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     14      8     45
      9      8     46
     27      8     46
      6      8     54
      3      8     46
     19      0      0
     21      8     45
     22      8     44
      0      0      0
      0      0      0
     18      8     46
     15      8     40
Latitude      N  36 deg  7 min 28.262 sec
Longitude     W 115 deg 13 min 27.729 sec
Altitude        682.6 meters above sea level
Date/Time     05/26/2011   12:33:13 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  7 min 28.507 sec
Hold Longitude     W 115 deg 13 min 27.747 sec
Altitude        687.9 meters above sea level
```

CDMA Site VG50XC176 /near proximity to LS Site 217, LS Upper and Lower Frequencies, w/Original GPS Antenna

Sprint Together with NEXTEL

Time (L2 both lower and high band)	Visible Satellites/Tracked Satellites (CTU 1)	Visible Satellites/Tracked Satellites (CTU 2)
11:49	8/8	8/8
11:53	8/8	8/8
11:56	8/8	8/8
11:58	8/8	8/8
12:01	7/1	7/1
12:05	7/0	7/0
12:07	7/0	7/0
12:10	7/0	7/0
12:12	7/0	7/0
12:14	7/0	7/0
12:15	7/0	7/0
12:16	7/7	7/7
12:18	7/7	7/7
12:20	7/7	7/7
12:22	6/6	6/6

This CDMA site is approximately 1/4 - 1/3 mile from LS site 217. When LS transmitted both upper and lower frequencies on 5/26, the GPS receiver was unable to track any satellites. The site fully recovered when the LS transmitter was turned off.

iDEN site NV6361R(with original GPS antennas)in near proximity to L2 site 217

GPS receiver status with no L2 “upper” and “lower” frequency transmission (on primary GPS feed)

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     52
     25      8     52
      5      8     50
     21      8     49
     12      8     44
      2      8     46
     26      8     44
     15      8     47
     18      8     44
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  6 min 46.980 sec
Longitude     W 115 deg 10 min  7.500 sec
Altitude        668.7 meters above sea level
Date/Time     05/26/2011   08:59:35 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  6 min 47.092 sec
Hold Longitude     W 115 deg 10 min  7.536 sec
Altitude        676.2 meters above sea level
```

GPS receiver status with L2 “upper” and “lower” frequency transmission “ON”

Note degradation of S/N levels

```
iSC> status gps
9 satellites tracked
9 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     43
     25      8     44
      5      8     39
     21      8     41
     12      8     41
      2      8     39
     26      8     35
     15      8     36
     18      8     36
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  6 min 47.008 sec
Longitude     W 115 deg 10 min  7.471 sec
Altitude        668.6 meters above sea level
Date/Time     05/26/2011   09:01:12 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  6 min 47.092 sec
Hold Longitude     W 115 deg 10 min  7.536 sec
Altitude        676.2 meters above sea level
```

Here the GPS primary GPS feed was used and a noticeable degradation in S/N was observed when L2 transmitted the upper and lower frequencies. The GPS receiver did continue to track all original satellites however. The primary GPS antenna was most likely shadowed somewhat from the L2 transmit antenna.

iDEN site NV6361R(with original GPS antennas)in near proximity to L2 site 217

GPS receiver status with no L2 “upper” and “lower” frequency transmission (on secondary GPS feed)

```
iSC> status gps
7 satellites tracked
7 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      8     50
     21      8     54
     25      8     53
      5      8     49
     26      8     47
     18      8     46
     15      8     47
      0      0      0
      0      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  6 min 46.630 sec
Longitude     W 115 deg 10 min  7.581 sec
Altitude        664.9 meters above sea level
Date/Time     05/26/2011   09:29:34 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  6 min 47.092 sec
Hold Longitude     W 115 deg 10 min  7.536 sec
Altitude        676.2 meters above sea level
```

GPS receiver status with L2 “upper” and “lower” frequency transmission “ON”

```
iSC> status gps
0 satellites tracked
0 satellites strictly tracked (4 are required)
     ID   Mode    S/N
     29      0      0
     21      0      0
     25      0      0
      5      0      0
     26      0      0
     18      0      0
     15      0      0
      0      0      0
      0      0      0
      0      0      0
      0      0      0
      0      0      0
Latitude      N  36 deg  6 min 46.626 sec
Longitude     W 115 deg 10 min  7.586 sec
Altitude        665.7 meters above sea level
Date/Time     05/26/2011   09:31:15 GMT
Position hold status is FALSE
Hold Latitude      N  36 deg  6 min 47.092 sec
Hold Longitude     W 115 deg 10 min  7.536 sec
Altitude        676.2 meters above sea level
```

Here the GPS secondary GPS feed was used and a total loss of tracked satellites was observed when L2 transmitted the upper and lower frequencies. The GPS receiver did continue to track all original satellites however. The secondary GPS antenna most likely had a clear LOS to the L2 transmit antenna. The GPS redundant (primary/secondary) antennas on this hotel rooftop were probably located on opposite side of the rooftop.

CDMA Site VG98XC050 /in near proximity to LS Site 217, LS Upper and Lower Frequencies, w/Original GPS antennas (Alarm Log)

Site	Alarm Details	Alarm Time
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 5:44
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 5:14
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 4:44
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 4:14
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 3:44
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 3:14
LV1-550	GLOBAL POSITIONING SYSTEM (GPS) 1	5/26/2011 2:44

The alarm log indicates there were GPS alarms occurring at this site when LS was transmitting the upper and lower frequencies on 5/26.

Sprint
Together with NEXTEL

GPS/AVIATION SPECIAL PURPOSE ANTENNAS

High Rejection GPS Timing Antennas

GPS-TMG-HR-26N, High Rejection 26dB With Enhanced Narrow Band Filtering

The GPS-TMG-HR-26 timing reference antennas feature a 26 dB amplifier and narrow band high rejection filtering specifically designed to support long-lasting, trouble-free deployments in congested cell-site applications with severe interference around the GPS L1 frequency.

The proprietary quadrifiliar helix design, coupled with multi-stage filtering provides superior out-of-band rejection and lower elevation pattern performance than traditional patch antennas.

The unique radome shape sheds water and ice, while eliminating problems associated with bird perching. The antenna may be purchased by itself or with pipe mounting hardware. Custom models or site kits options are also available. The antenna label and collar mount are color coded red for differentiation purposes.

This antenna is made of materials that fully comply with provisions stipulated by EU directives RoHS 2002/95/EC.

GPS-TMG-HR-26N

GPS-TMG-MNT-R

GPS-TMG-HR-26NCM

Antenna Element Electrical Specifications

Frequency Band	Antenna Gain	Nominal Impedance	VSWR	Polarization	Connector
1575.42 +/- 10 MHz	3.5 dBic	50 ohms	≤1.5:1	Right hand circular	N, female (one - bottom fed)

Mechanical Specifications

Antenna Dimensions	Shipping Dimensions	Antenna Weight	Shipping Weight	Radome Color
5.0” H x 3.2” D (126 H x 81 mm)	7.5” L x 4.4” W x 3.8” D (190 L x 112 x 96 mm)	0.6 lbs (0.3 kg)	1.9 lbs (0.9 kg)	White

Environmental Specifications

Temperature Range	Humidity
- 40°C to + 85°C	95%

Mounting

All mounting options fit pipes of 1”-1.45” (25 mm-37 mm) maximum diameter.

Model	Options
GPS-TMG-HR-26N	Antenna Only. Does not include mounting hardware.
GPS-TMG-HR-26NCM	Includes red powder coated collar mount (GPS-TMG-MNT-R)

PCTEL

Low Noise Amplifier Specifications

Frequency Band (MHz): 1575.42 +/- 1.2 MHz
Amplifier Gain: 26.5 dB +/- 3 dB
Nominal Impedance: 50 ohms
Output VSWR: < 2.0:1
Noise Figure (including pre-selector): ≤ 4.0 dB @ +25°C (typ.) ≤ 4.5 dB @ +25°C (max.)
Operating DC Voltage: 3.3- 12.0 V (regulated)
Survival DC Voltage: 24V
DC Current: ≤ 40 mA @ 5V
Filtering: 4-stage filtering including pre-selector
Out-of-Band Rejection: ≥ 65 dB @ 1559 MHz ≥ 65 dB @ 1625 MHz

*Special order. Please contact PCTEL Customer Service for ordering detail and addititional mounting options

PCTEL, Inc. WEB: www.antenna.pctel.com

Appendix H.1.9

Analysis of field test results.
Las Vegas. Base station 53.
Rural/Open sky.

Main conclusions.

LTE interference influence has dramatic and clearly unacceptable character even at a considerable distance from the transmitting station.

It appears in either strong degradation of GPS signal level (more than 5 dB) or immediate loss of tracking all satellites.

For some cases the obtained results are difficult to explain. Corresponding points in graphs are marked with "?!" .

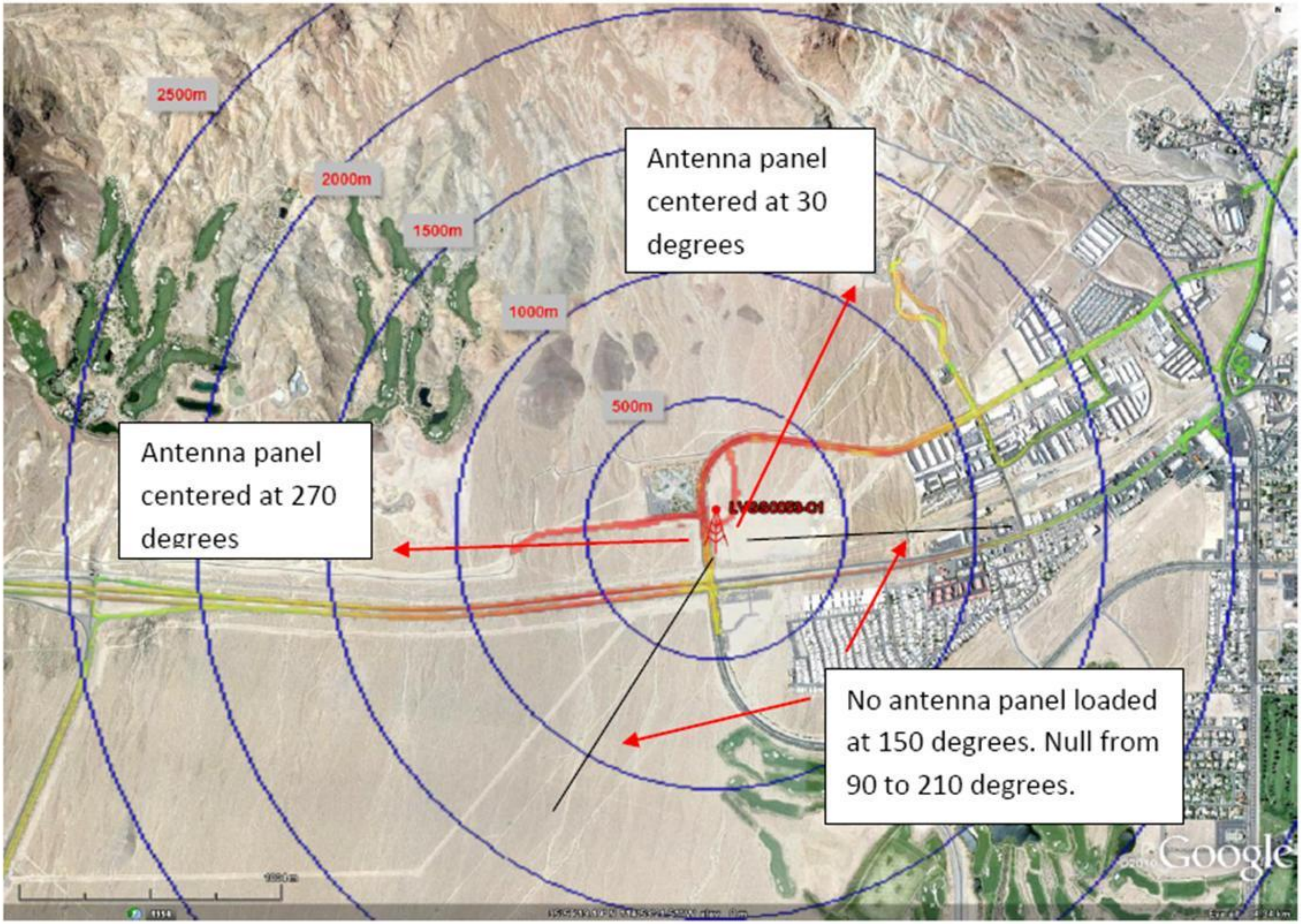
It should be noted that in motion interference influence mostly reduces. It especially noticeable in observations after point 22 (graphs in file SN_3.bmp, last page of the report).

All details are given in tables and graphs below.

Similar to tests in anechoic chamber, in real observation conditions interference practically does not affect accuracy of code and phase measurements until the very moment of loss of tracking. Corresponding graphs of measurement errors are not presented in the report.

Field Test Team

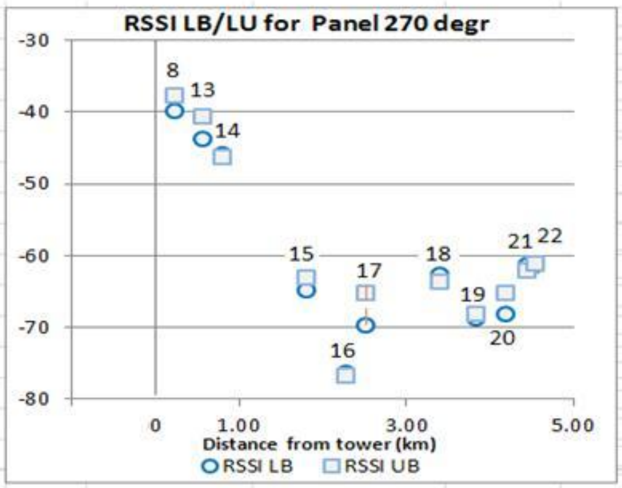
Trimble: Received power at Tower 53. Only two antenna panels at 30 and 270 degrees were loaded.

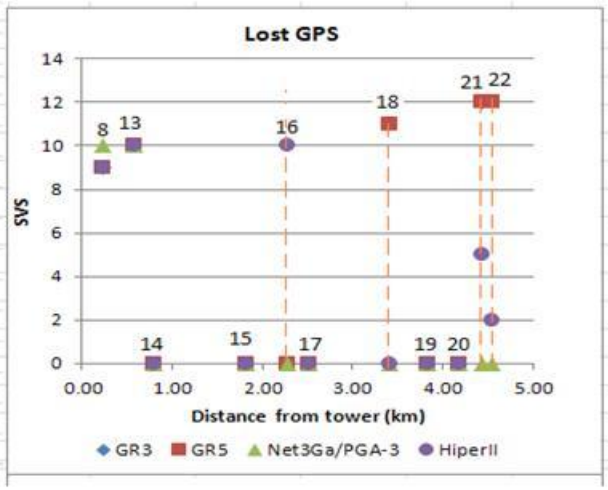


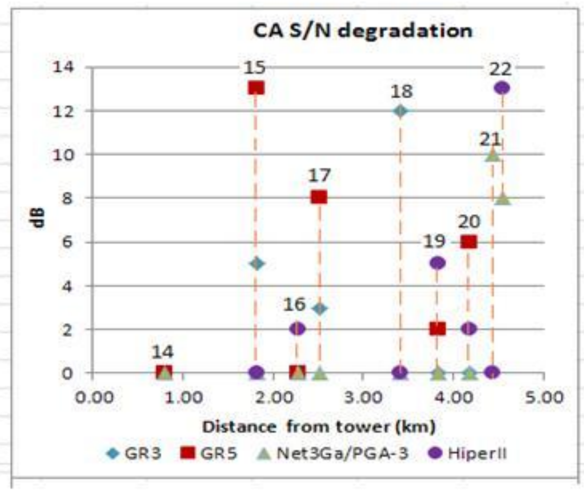
TOPCON TEST POINTS

LSQ Power Interference, Lost of GPS and GPS SN Degradations on difference points (locationns). Las Vegas, Base Stantion # 53

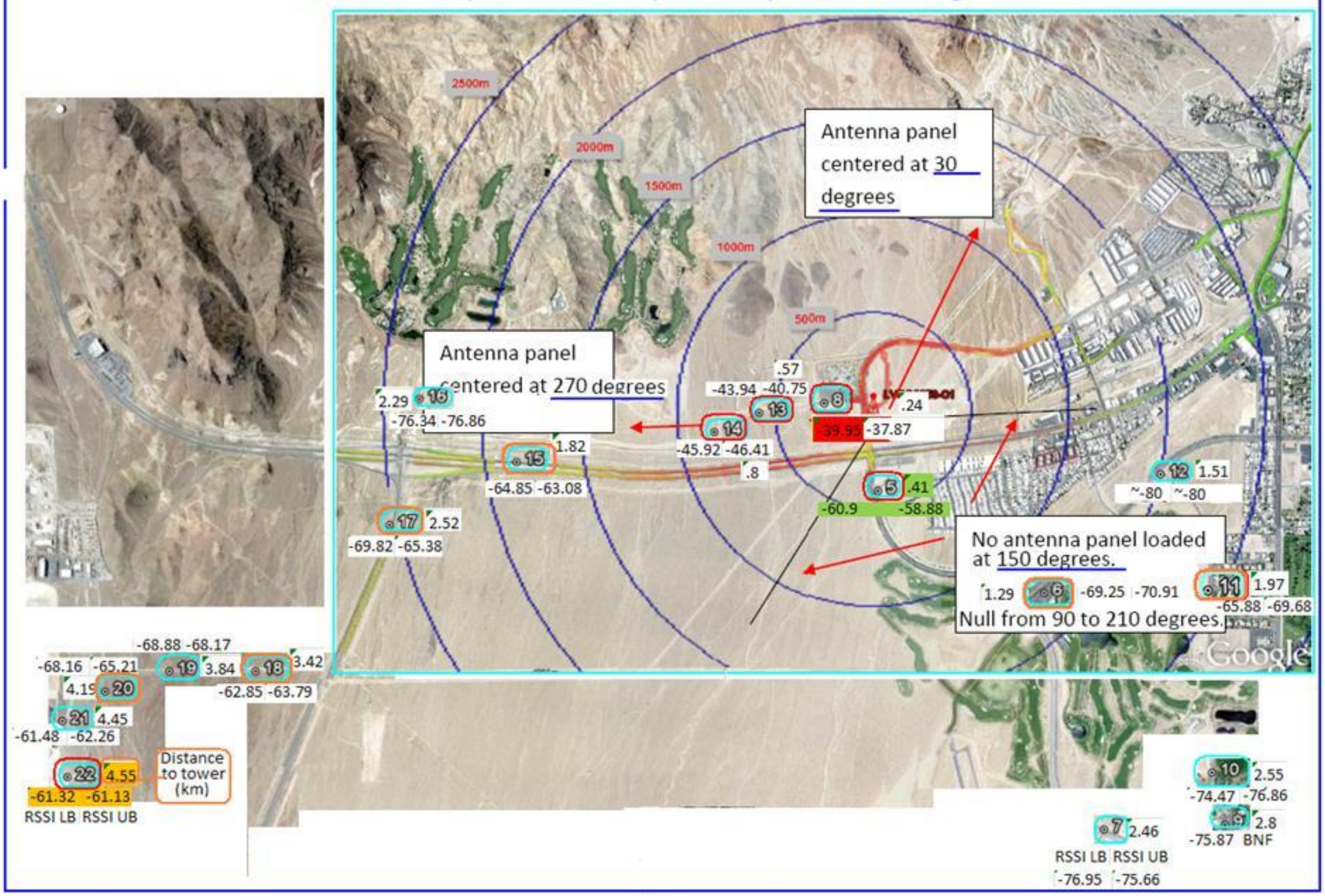
					GR3		GR5		Net3Ga/PGA-3		HiperII					
Location	Distance to tower (km) / Base St Panel	Distance to tower	RSSI LB	RSSI UB	Lost GPS	CA S/N Degradation (dB)	Lost GPS	CA S/N Degradation (dB)	Lost GPS	CA S/N Degradation (dB)	Lost GPS	CA S/N Degradation (dB)	Arrived at site	Left Site	Lat	Long
1, 2, 3, 4					Invalid data. Lightsquared cabling error											
8	.24 (Panel 270)	0.24	-39.95	-37.87	9	_	9	_	10	_	9	_	8:54:00	9:08:00	35.58.11.9743	114.52.14.4407
13	.57 (Panel 270)	0.57	-43.94	-40.75	10	_	10	_	10	_	10	_	9:54:20	10:01:00	35.58.10.6093	114.52.27.6134
14	.8 (Panel 270)	0.80	-45.92	-46.41	0	0	0	0	0	0	0	0	10:16:30	10:17:15	35.58.07.4634	114.52.36.7259
15	1.82 (Panel 270)	1.82	-64.85	-63.08	0	5	0	13	0	0	0	2	10:18:30	10:33:30	35.58.02.3926	114.53.16.8855
16	2.29 (Panel 270)	2.29	-76.34	-76.86	0	0	0	0	0	0	10 ?!	_	10:36:20	10:38:40	35.58.12.6729	114.53.36.5506
17	2.52 (Panel 270)	2.52	-69.82	-65.38	0	3	0	8	0	0	0	0	10:40:30	10:43:15	35.57.52.0186	114.53.42.9117
18	3.42 (Panel 270)	3.42	-62.85	-63.79	0	12	11	_	0	0	0	5	10:48:00	11:02:30	35.57.27.6101	114.54.10.9579
19	3.84 (Panel 270)	3.84	-68.88	-68.17	0	0	0	2	0	0	0	2	11:04:30	11:06:40	35.57.27.5693	114.54.28.8512
20	4.19 (Panel 270)	4.19	-68.16	-65.21	0	0	0	6	0	0	0	0	11:12:20	11:14:50	35.57.24.1329	114.54.42.2739
21	4.45 (Panel 270)	4.45	-61.48	-62.26	12	_	12	_	0	10	5	13	11:17:00	11:34:00	35.57.19.1796	114.54.51.1976
22	4.55 (Panel 270)	4.55	-61.32	-61.13	12	_	12	_	0	8	2	13	11:36:10	11:37:50	35.57.09.7101	114.54.50.3263
5	.41 (Panel 150)	0.41	-60.9	-58.88	0	0	0	12	0	0	9/2	2	8:12:00	8:32:00	35.57.57.6286	114.52.03.3662
6	1.29(Panel 150)	1.29	-69.25	-70.91	0	1	0	4	0	0	0	1	8:36:30	8:39:00	35.57.40.7780	114.51.29.3224
16 7	2.46(Panel 150)	2.46	-76.95	-75.66	0	0	0	0	0	0	0	0	8:42:00	8:46:30	35.57.01.3453	114.51.16.4677
9	2.8(Panel 150)	2.80	-75.87	BNF	0	0	0	0	0	0	0	0	9:13:20	9:19:20	35.57.02.1935	114.50.51.7305
10	2.55(Panel 150)	2.55	-74.47	-76.86	0	0	0	0	0	0	0	0	9:22:00	9:34:00	35.57.10.9104	114.50.54.5986
11	1.97(Panel 150)	1.97	-65.88	-69.68	0	0	0	3	0	0	0	3	9:39:30	9:43:00	35.57.38.7809	114.50.57.0929
12	1.51(Panel 150)	1.51	-80	-80	0	0	0	0	0	0	11 ?!	0	9:45:40	9:48:00	35.58.00.3355	114.51.06.0266





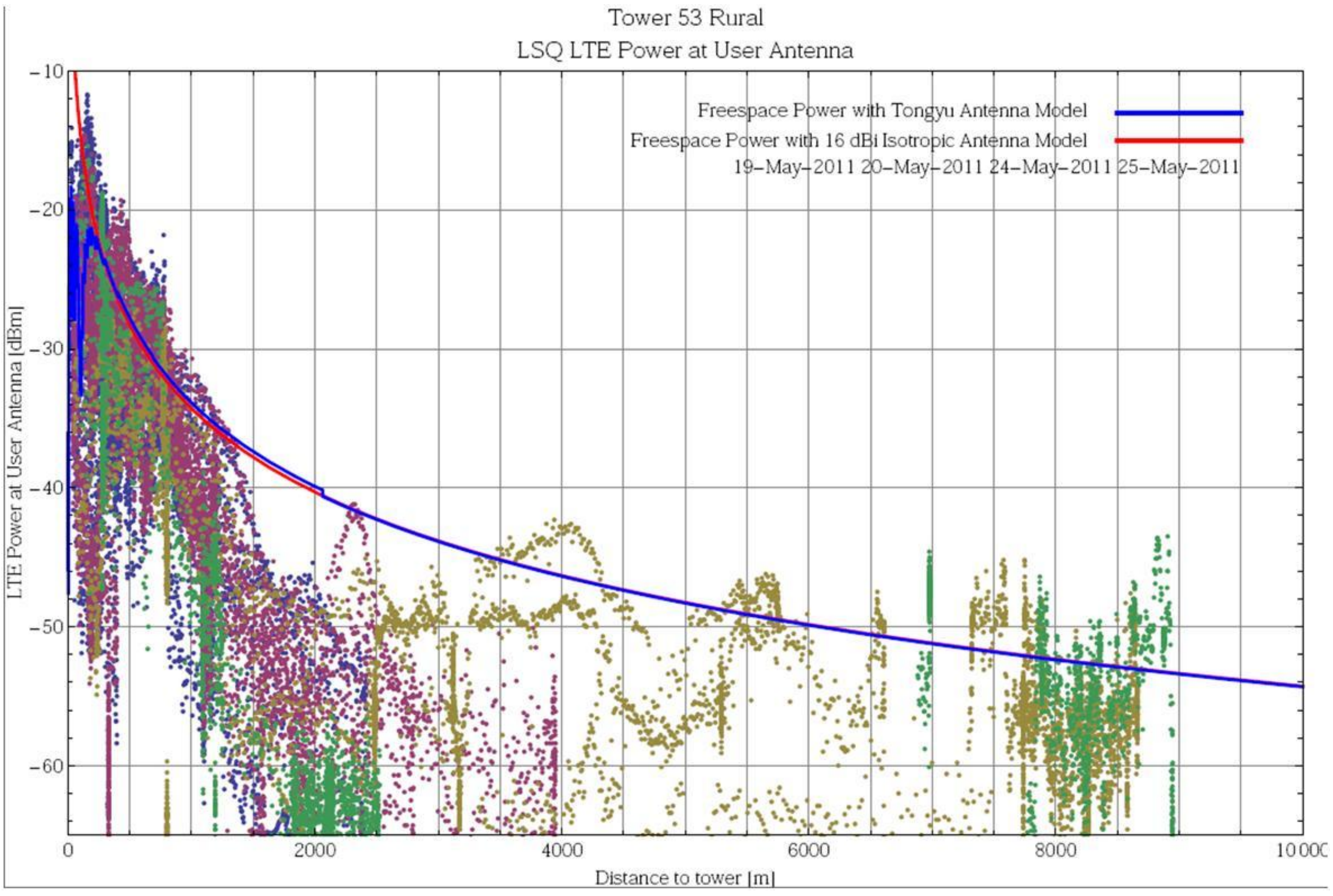


Topcon: Received power at Tower 53. Only two antenna panels at 30 and 270 degrees were loaded.

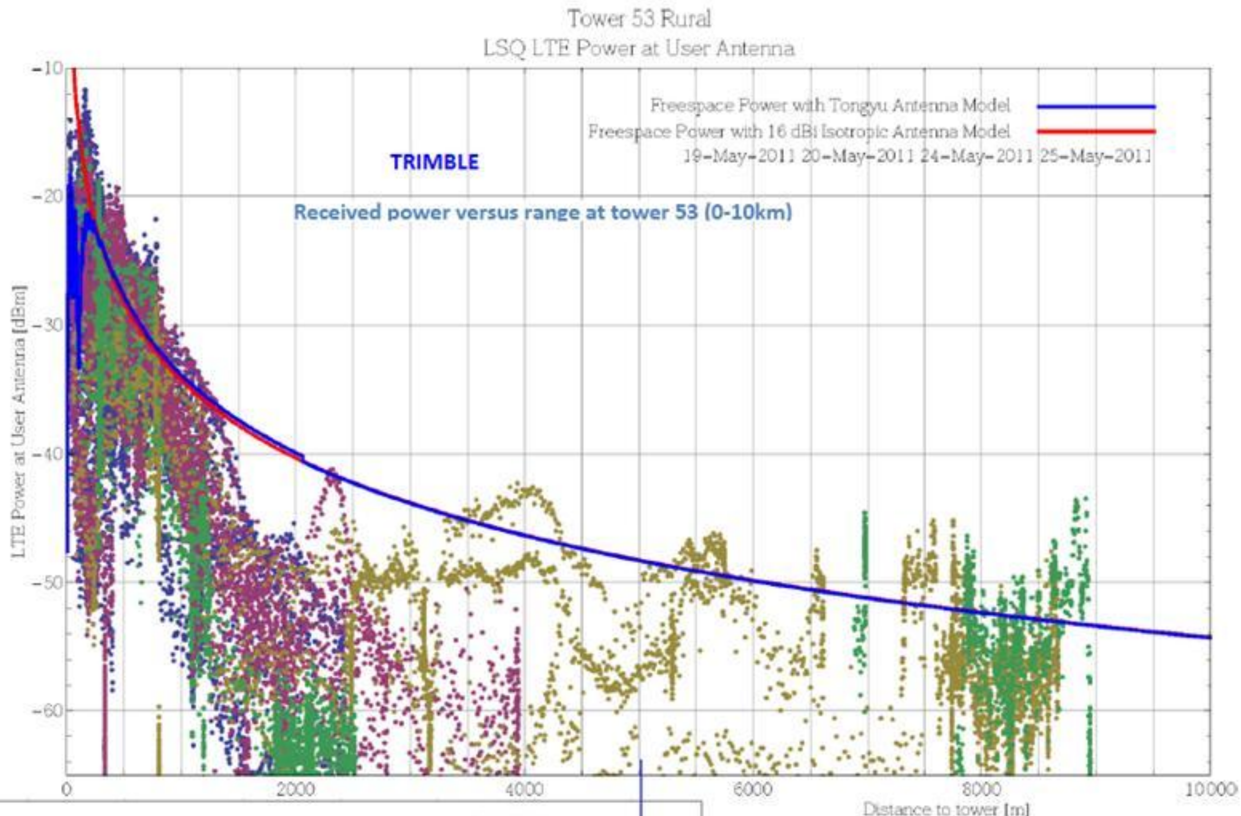


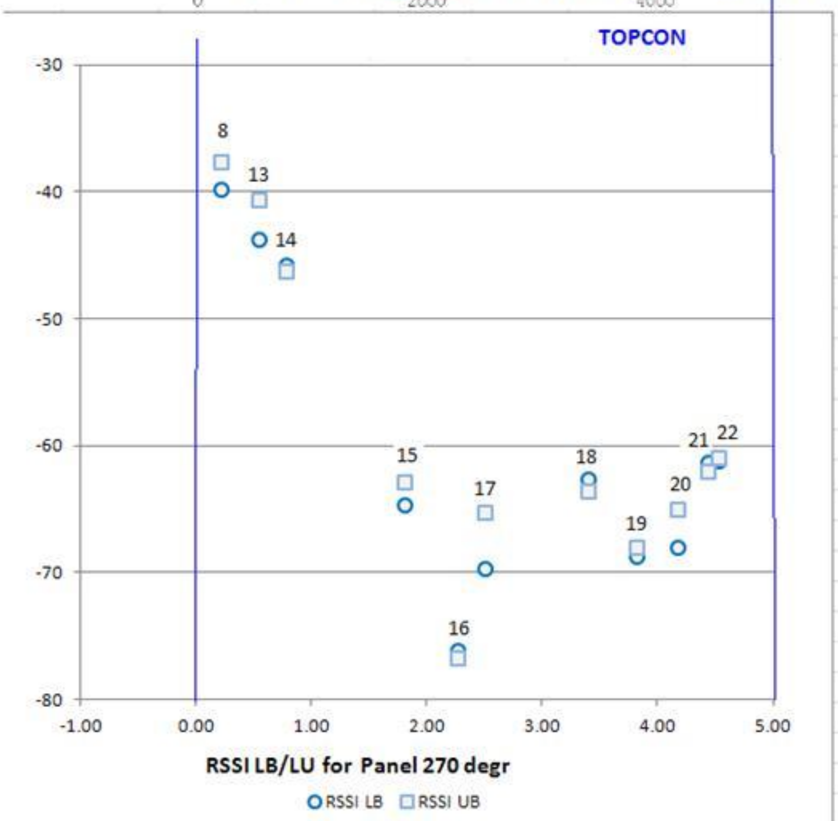
Point	RSSI LB	RSSI UB	Distance to tower (km)	GPS			
				GR3	GR5	Net3Ga	HiperII
5 (Panel 150)	-60.9	-58.88	.41	10	10	10	10
6 (Panel 150)	-69.25	-70.91	1.29	11	11	11	11
7(Panel 150)	-76.95	-75.66	2.46	11	12	12	11
8(Panel 270)	-39.95	-37.87	.24	0	0	0	0
9(Panel 150)	-75.87	BNF	2.8	10	10	10	10
10 (Panel 150)	-74.47	-76.86	2.55	10	10	10	10
11(Panel 150)	-65.88	-69.68	1.97	11	10	11	11
12 (Panel 150)	~-80	~-80	1.51	11	11	11	11
13 (Panel 270)	-43.94	-40.75	.57	0	0	0	0

Point	RSSI LB	RSSI UB	Distance to tower (km)	GPS			
				GR3	GR5	Net3Ga	HiperII
14(Panel 270)	-45.92	-46.41	.8	0	0	0	0
15(Panel 270)	-64.85	-63.08	1.82	10	10	10	10
16(Panel 270)	-76.34	-76.86	2.29	10	10	8	10
17(Panel 270)	-69.82	-65.38	2.52	11	11	11	10
18(Panel 270)	-62.85	-63.79	3.42	11	5	11	10
19(Panel 270)	-68.88	-68.17	3.84	9	9	9	9
20(Panel 270)	-68.16	-65.21	4.19	10	10	11	10
21(Panel 270)	-61.48	-62.26	4.45	11	11	11	11
22(Panel 270)	-61.32	-61.13	4.55	0	0	13	9



Tower 53 Rural
LSQ LTE Power at User Antenna
Freespace Power with Tongyu Antenna Model
Freespace Power with 16 dBi Isotropic Antenna Model
19–May–2011 20–May–2011 24–May–2011 25–May–2011
LTE Power at User Antenna [dBm]
Distance to tower [m]
−10
−20
−30
−40
−50
−60
0
2000
4000
6000
8000
10000



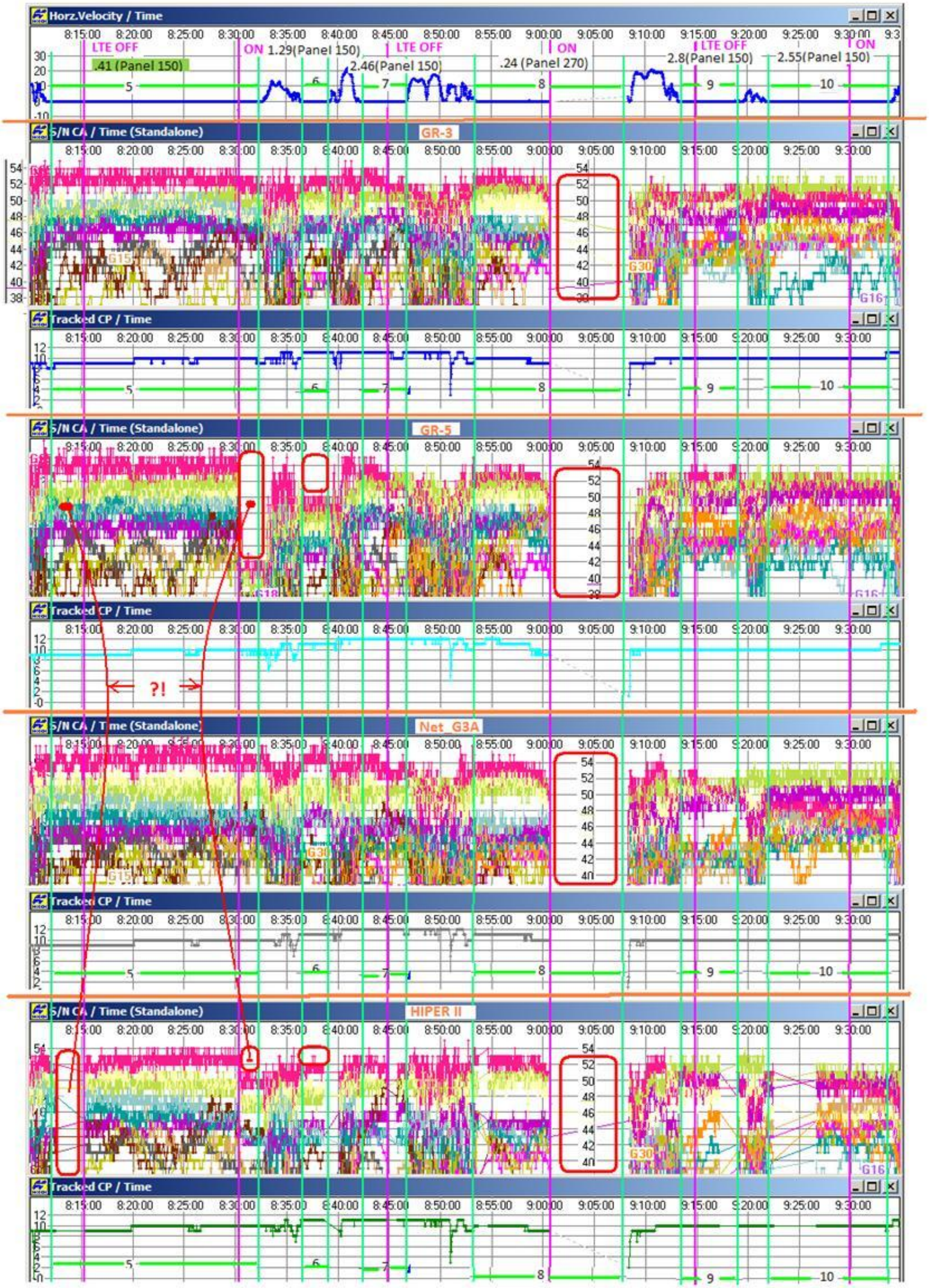


from 5/24/2011 8:54 AM

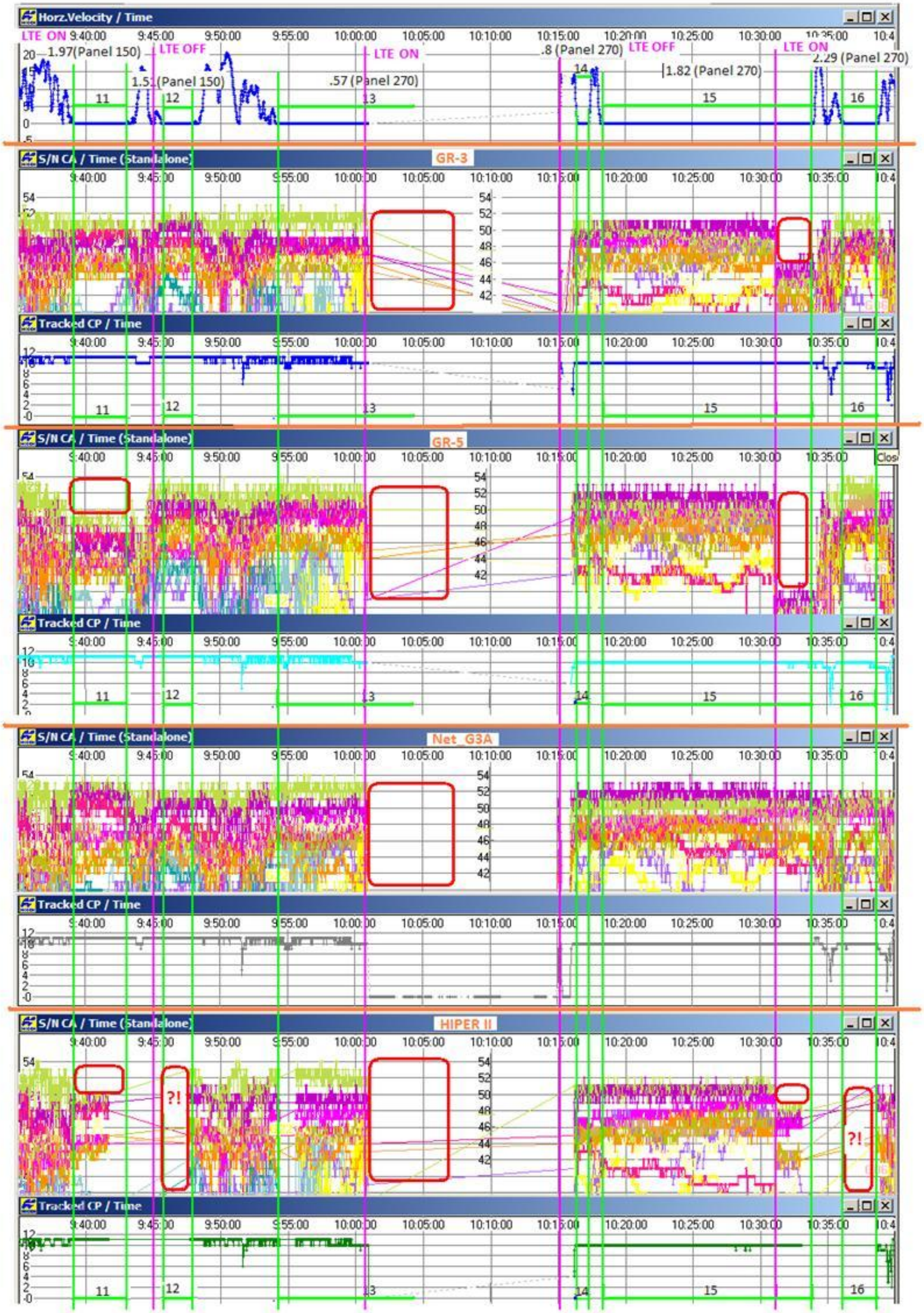
to 5/24/2011 11:37 AM

Location #	Distance to tower (km)
8	0.24
13	0.57
14	0.80
15	1.82
16	2.29
17	2.52
18	3.42
19	3.84
20	4.19
21	4.45
22	4.55

Locations # 5 -10 / Las-Vegas LiveSky/ Tower 53 24-May-2011/



Locations # 11-16 / Las-Vegas LiveSky/ Tower 53 24-May-2011/



Locations # 16 -22 / Las-Vegas LiveSky/ Tower 53 24-May-2011/